# Working Paper

FB 87-06

# OPERATOR WORKLOAD (OWL) ASSESSMENT PROGRAM FOR THE ARMY: RESULTS FROM REQUIREMENTS DOCUMENT REVIEW AND USER INTERVIEW ANALYSIS

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Draft Technical Report 2075-2

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22 May 1987


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Task Report
Contract No. MDA903-86-C-0384
Item No. 0002AD

## EXECUTIVE SUMMARY


This report is one of a series describing a program for the development and validation of a methodology for estimation and evaluation of operator workload (OWL) in Army systems. It presents the results of Task 2 of Analytics' contract with the Army Research Institute (ARI) to "Identify Army Requirements Regarding OWL, Select Specific Army Systems to Analyze , and Provide Outline of OWL Products". Included are the results of component subtasks: (2.1) Review Army Requirements and Reports, (2.2) Assess User Needs, (2.3) Outline Final Products, and (2.4) Select Prototype Army Systems to Evaluate. The overall purpose of this report is to characterize existing and future Army requirements and needs for OWL assessment, to tailor the OWL program to meet these requirements and needs, and to identify emerging Army systems that are appropriate candidates for exercising families of OWL assessment techniques.

Based on the review of Army documents and regulations, there seemed to be a void in specific guidance concerning the implementation of OWL assessment during the Materiel Acquisition Process (MAP). Such lack of specific guidance concerning OWL assessment was further substantiated in our interviews as well as from questionnaire data with Army personnel who play integral roles during the MAP. Our assessment of these findings has resulted in tailoring the proposed products (e.g., Outlines of OWL Handbooks and Pamphlet) to meet the apparent need for OWL guidance throughout the MAP. In addition, recommendations are offered in the report for integrating our efforts with existing Army programs (e.g., MANPRINT) to assure that OWL receives adequate consideration throughout the MAP. With respect to selecting prototype Army systems to evaluate, candidate systems are offered that allow a wide-range of OWL techniques to be employed as well as providing opportunities to make substantial and positive contributions toward impacting the design of these systems .

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# 1. INTRODUCTION

This report is one of a series describing a program for the development and validation of a methodology for estimation and evaluation of operator workload (OWL) in Army systems. It presents the results of Task 2 of Analytics' contract with the Army Research Institute (ARI). The components comprising this task are:

- Review Army Requirements
- Assess User Needs
- Outline Final Products
- Select Prototype Army Systems to Evaluate

The overall purpose of this report is to: Present Army requirements and needs as obtained throughout document review and interviews regarding OWL issues and concerns, outlines of final products based on those requirements and needs, and to suggest emerging Army systems for OWL evaluation.

## 1.1 Overview of Program Progress

The OWL program is one of several focusing on the practical problem of determining what the Army can and should do to assure that systems can be adequately operated by prospective personnel. As new technologies are implemented with greater degrees of computer-interaction, there is growing concern questioning the ability of soldiers to operate these systems. With regard to OWL, pertinent questions include, "How much information processing, decision making and other cognitive tasks can system operators handle?" and "Under what time and other limitations may operators continue to function before overload and performance degradations occur?" These OWL questions need to be addressed during system development to avoid marginal or inoperable systems.

The primary focus of the present program is with single operator workload. For present purposes, OWL may be thought of as a representation via predictive and empirical assessment techniques of a human operator's relative limitation in the capability to perform work. Here, relative limitation implies a functional relation between (1) actual operator performance in the context of mission requirements and (2) the operator's ultimate performance capability. Our emphasis is on the cognitive, perceptual and psychomotor

aspects of workload, although it is recognized that there are physical workload issues more associated with maintainer tasks (lifting, carrying, etc.).

A necessary step in the process of providing practical assistance to the Army is to understand current procedures and requirements for addressing operator workload in the Materiel Acquisition Process (MAP). This understanding will form the basis for development of useful guidance for the Army community. To gain this understanding two avenues were employed. First, the procedural aspects of the Army MAP were reviewed via written documents. Second, discussions were conducted with military and civilian personnel within the Department of the Army (DA) to further understanding of their roles in the MAP, their current methods of addressing OWL, and their thoughts on what could be provided to them that would be most useful in their jobs. This process of understanding and its results are discussed later in the report.

From the comments and suggestions gathered, draft outlines of the three handbooks have been developed for this report. The handbooks which will be developed during a later effort (Task 5) will form the basis of the guidance provided to the Army users for addressing operator workload The guidance will result from a critical review of the current scientific literature concerning definition, prediction, measurement and evaluation of workload which will be accomplished as part of the follow-on in Task 3. The suggested guidance and methodologies will be validated subsequently by application to specific Army systems (Task 4). However, the systems have been chosen as part of the present effort so that familiarization with system specifics and necessary coordination with the appropriate Army organizations can begin. As will be seen, the task of choosing prospective systems was assisted by the interview process; those most familiar with what systems are most appropriate were some of the same individuals with whom we were speaking about OWL requirements and needs. The application of the techniques to the three selected systems will serve as the means to validate the practical approach being devised as well as providing benefits for the systems and the Army.

## 1.2 Organization of Report

The body of this report presents the results of Task 2. Section 2, in particular, discusses the review of documents that describe the Army Materiel Acquisition Process and how operator workload is currently addressed within the MAP. Subsequently, the

results of the interviews of members of the Army community concerning their roles and responsibilities (both current and projected) in the MAP and their viewpoints concerning OWL are presented in Section 3. In Section 4, the concepts and rationale for the final products are discussed and the product outlines are presented. The descriptions of Army systems that have been selected for assessment and validation of OWL assessment techniques are presented in Section 5. Finally, Sections 6 and 7 discuss other progress to date as well as plans for future tasks of the OWL program.

# 2. REVIEW OF ARMY REQUIREMENTS

## 2.1 Introduction

The Army maintains a continuous effort to field the most capable force possible. When changes in doctrine, organization or training cannot eliminate identified deficiencies, then a decision may be made to eliminate the deficiencies through equipment acquisition (i.e., procuring hardware systems). The process by which new equipment is conceived, designed, developed and procured is given in regulations, directives, and other documents.

As part of the OWL project effort, a review of the documents and regulations that drive Army materiel acquisition was performed. The review was one method to gain an understanding of the Army system of materiel acquisition -- the way the requirements for materiel are developed, the information needed to develop requirements, how the requirements are translated to hardware design and development, and the roles of members of the Army community who manage or perform these tasks. The document review also was a means of identifying guidance inconsistencies and voids.

This chapter describes the approach used to understand the Army acquisition process, how the issue of OWL is currently addressed in the process, what documents provide guidance and where we see OWL issues potentially being addressed in the acquisition process.

## 2.2 Approach

A series of documents were reviewed for two major purposes. First, we needed to assure a comprehensive understanding of the documented Army Materiel Acquisition Process (MAP). For this purpose, a detailed review of both directly and indirectly relevant documents was conducted to identify (1) if and where OWL issues are considered and, (2) how they are currently addressed.

The process was an iterative one -- as more relevant documents were identified, ones read previously were reread for increased information and understanding. Additionally, the interview and questionnaire methodology employed to assess Army user

needs (see Section 3.) yielded information that added to our understanding of both the MAP and associated issues regarding the assessment of OWL. The interviews provided for iterative document review as well as further contacts.

The following sections, then, will present discussion of our review. The discussion of the Army Materiel Acquisition Process in Section 2.3 deals with the process as described in Army Regulations (ARs) and other written documents. Of particular importance is the recent emphasis on the Army Streamlined Acquisition Process (ASAP) and other acquisition alternatives, such as Non-developmental Items (NDI) and product improvements (P3I, PIP). Section 2.4 describes the few places in the reviewed documents where OWL is mentioned. In addition, the review was expanded to include mention of Human Factors Engineering (HFE) and MANPRINT where OWL concerns may be expected to be of greatest interest and importance. Finally, several conclusions are drawn from the document review of OWL and recommendations are made.

Some documents are more important than others and specific reference will identify those when appropriate. In all cases, the documents reviewed were the latest editions that could be obtained. It is noteworthy, as can be seen by the effective dates of many of the ARs, much guidance has been recently revised and published. In one sense then, this discussion is based on guidance available within the present slice of time. However, the general process of identifying requirements and developing/acquiring equipment to fulfill the requirements remains essentially unchanged. The discussions that follow will make specific reference to the latest guidance available, but will also include an overall perspective of the Army MAP and OWL issues in MAP.

## 2.3 The Army Materiel Acquisition Process

### 2.3.1 Introduction

There has been a great deal of innovation and adjustment in the acquisition process during this decade. Incorporation of the recommendations of bodies such as the Packard Commission have resulted in many changes in the way the Department of Defense and the Army approach developing and fielding new materiel. Four broad categories of acquisition methods are recognized. These are:

- Traditional Process
- Army Streamlined Acquisition Process (ASAP)
- Non-Development Items (NDI)
- Product Improvement.

The traditional process is described in a degree of detail which may seem out of proportion to its modern application. This approach is taken because most persons with some experience in materiel acquisition are familiar with the traditional process and use it for comparisons. The other development methods are described using the traditional process as a baseline. This section describes the Army Materiel Acquisition Process (MAP) and projects how OWL considerations could or should be integrated into the MAP.

Major reference sources for this section are AR 70-1, Systems Acquisition Policy and Procedures, AR 71-9, Materiel Objectives and Requirements and DARCOM (now AMC) / TRADOC Pamphlet 70-2, Materiel Acquisition Handbook. Major implementing regulations in specific disciplines, such as AR 70-10, Test and Evaluation, and AR 602-2 MANPRINT have also been useful sources. AMC Regulation 70-52, System Engineering, is a relatively new publication which may have impact on incorporating OWL enhancements to new or improved materiel. It provides renewed emphasis to the importance of the systems engineering process in materiel development. Department of the Army Pamphlet 11-25, Life Cycle System Management Model for Army Systems, has also been useful. This latter reference is, however, over ten years old and must be used with great caution. Many of the features of the model have been significantly impacted by recent changes in the acquisition process. For instance, the MANPRINT program has had a considerable amount of influence on the treatment of manpower, training, human factors and safety issues. Some caution must also be used in applying DARCOM/TRADOC Pamphlet 70-2.

### 2.3.2 The Traditional Materiel Acquisition Process

#### 2.3.2.1 Overview (AR 70-1,Pam 70-2)

The Traditional acquisition process is divided into five phases. They are the (1) Program Initiation, (2) Concept Exploration, (3) Demonstration and Validation, (4) Full Scale Development (FSD), and (5) Production and Deployment Phases. Production and Deployment may be divided into Low Rate Initial Production and a full Production and

Deployment Phase. Each succeeding phase takes a materiel requirement from a broad concept to successively more precisely specified, producible and supportable materiel solution to the Army's operational needs. The traditional process typically consumes about 11 to 15 years from program initiation to fielding.

OWL considerations and trade-offs should be made early in this life cycle. A commonly accepted rule of thumb holds that 70 percent of system life cycle costs are set at or before the system proceeds into the Demonstration and Validation Phase ( Advanced Development ). Paralleling this is the observation of a similar accelerating decline in design flexibility. Figure 2.3.2-1 illustrates the traditional process and where OWL evaluations and predictions may be used most appropriately. OWL consideration must be made in the early phases of development because the costs of modifying design later accelerate and options similarly decline as the system proceeds further into the MAP.

#### 2.3.2.2 Program Initiation (AR 70-1, AR 71-9, PAM 70-2)

Activities which result in program initiation activities can be divided into two broad categories. These are mission and operations oriented activities and science and technology oriented activities. Mission and operations oriented activities include threat assessments, conduct of Mission Area Analyses (MAA), development of long range plans such as the Battlefield Development Plan (BDP) and the Mission Area Materiel Plan (MAMP), and preparation of the DA Long Range Research Development and Acquisition Plan (LDRRDP).

# OWL IN THE NORMAL MATERIEL LIFE CYCLE

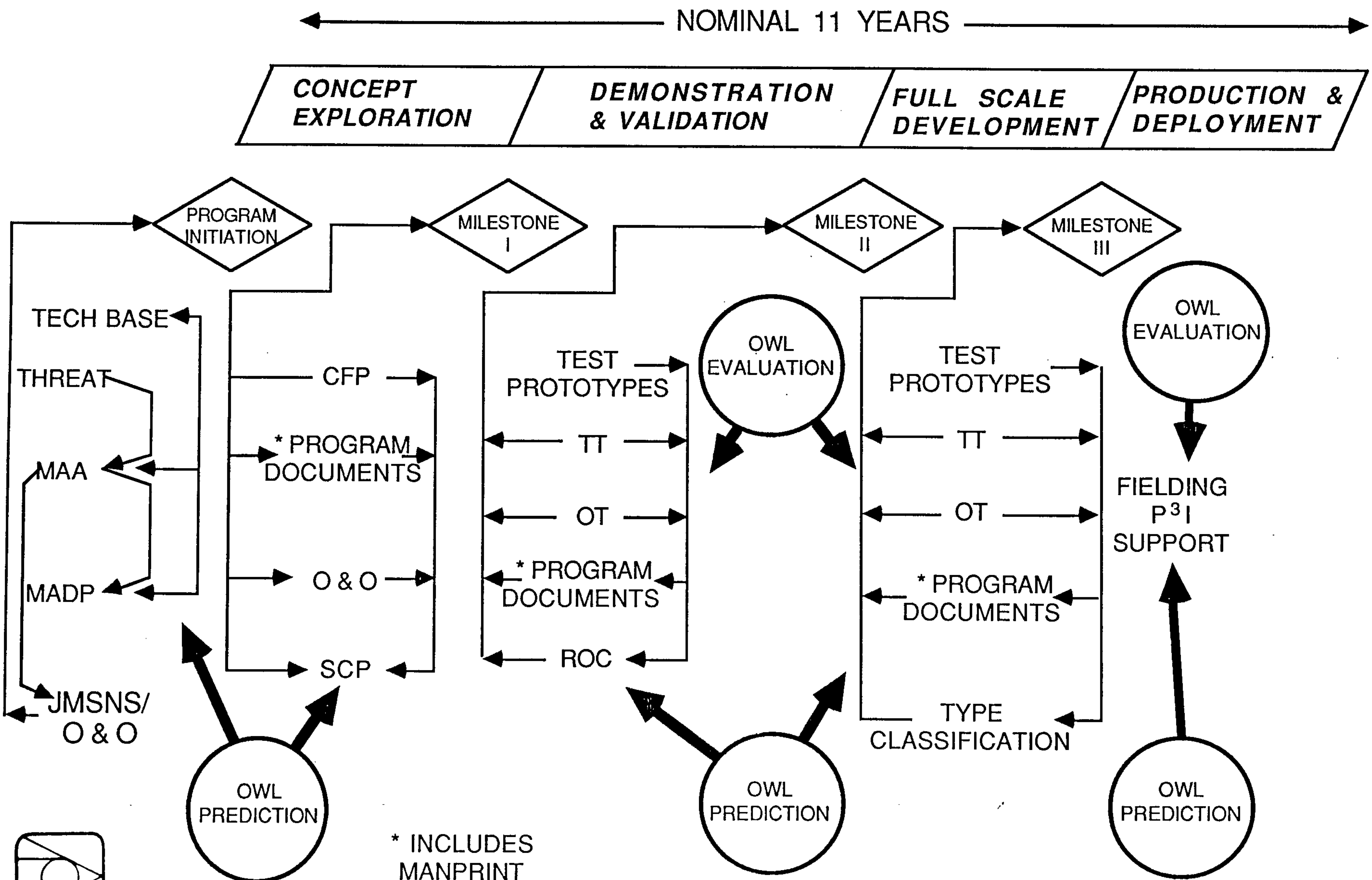


Figure 2.3.2-1 OWL Considerations in the Traditional MAP

Science and technology oriented activities include basic and exploratory research and other technical base activities which lead to new or improved technological capabilities. The operations and mission oriented activities may lead to the development and submission of a Justification for Major Systems New Start (JMSNS), upon which a major DoD program may be based. An Operational and Organizational Plan (O&O Plan), is the basis for initiating a designated acquisition program (DAP) at the Department of Army level or non-major development program at levels below DA. The O&O Plan is also a part of the JMSNS. OWL considerations have potential contributions to all these activities. For example, basic and exploratory research, and technical base programs may directly address OWL issues. Mission Area Analyses (MAAs) may conclude that operational work load deficiencies may constitute future program drivers. The O&O plan may be constrained by OWL considerations.

The mission oriented activities include the thirteen specific MAAs which have been conducted and are periodically updated by the US Army Training and Doctrine Command (TRADOC). These analyses provide an in-depth examination of the Army's ability to perform its fundamental combat missions (e.g. Close Combat, Fire Support, Air Defense, NBC, etc.). OWL considerations may limit specific operational capabilities addressed within given mission areas. These would be expected to be statements of OWL limitations based on evaluation of existing capability.

The BDP and MAMP are broad examinations of the Army's operational and materiel capabilities. They are based on the MAA and prioritize future program efforts based on the DA LRRDAP. If a materiel solution is considered appropriate to address a mission area deficiency, that solution is supported in an O&O Plan. The O&O plan may be prepared as a stand-alone document or may be an attachment to the JMSNS. OWL considerations play an important role in developing the O&O plan. The O&O plan (Appendix C, AR 71-9) describes how a system will be integrated into the force structure, and deployed, operated and supported during both peace time and war time. It ultimately supports the preparation of detailed integrated logistic support planning, basis of issue planning, and broad personnel planning. MANPRINT considerations and personnel impacts are a specific section within the O&O Plan. Assessment of these personnel impacts need to be supported by OWL predictions and evaluations for similar existing systems.

Technical base activities include basic research and exploratory development which address questions which impact on future operational capabilities. OWL issues need to be

addressed within the framework of these research programs. Technical base activities are prioritized and funded in accordance with Science and Technology Objectives (STOs) which are established and prioritized in the HQ DA LRRDAP. The STOs are based on operational deficiencies noted in MAAs.

Program initiation results when it is recognized that an operational deficiency exists and it is likely that a materiel solution will be effective. Typically, a Special Task Force (STF), Special Study Group (SSG) or acquisition team is formed on approval of the O&O Plan or JMSNS. Secretary of Defense guidance may be established for major programs in a Program Decision Memorandum (PDM). The PDM provides broad program guidance from the DoD level for systems for which a JMSNS is required. The STF/SSG or Acquisition Team carry the program responsibilities until the program enters the Concept Exploration Phase.

#### 2.3.2.3 Concept Exploration (AR 70-1, AR 71-9, AMC Reg 70-52, Pam 70-2, AR 602-2)

During concept exploration, technical alternatives to meeting the stated material need and supporting that system are identified and explored. The competing alternatives include incorporation of new technology, adoption of non-development items (NDI), and product improvement of existing hardware. Market surveys are conducted, bread board and experimental prototypes are developed and tested, and information regarding development risks and program alternatives are developed and assessed. Final system concepts are ultimately selected and plans addressing training, logistics, and future testing are developed. An Acquisition Strategy (AS) is developed which guides the conduct of the future program.

The concept exploration phase may be the most critical for the application of OWL concepts. Trade offs addressing technical approaches and training and support approaches will impact on virtually all future related development activities. OWL issues addressed in the trade off determination (TOD), trade off analysis (TOA) and development of the best technical approach (BTA) will become embedded in the program for its entire life. OWL considerations will also impact on other studies and analysis conducted during this phase. System engineering activities commence and serve as a significant tool for integrating OWL requirements into the system. Update of the O&O plan and development of cost and operational effectiveness analysis, development of base line cost estimates and independent

parametric cost estimates will all be impacted by OWL considerations. Typical concept formulation activities are described briefly with comments on their relationship to operator workload issues. These activities include :

- O&O Plan -- The previously developed O&O Plan is revised. Requirements stated within the O&O Plan should be based on an understanding of potential OWL impacts. OWL assessments based on similar systems may be employed in developing the plan.
- Concept Formulation Package -- The CFP consists of the Trade Off Determination (TOD), the Trade Off Analysis (TOA), the Best Technical Approach (BTA), and the Cost and Operational Effectiveness Analysis (COEA). These analyses are packaged as a part of the CFP under a cover letter which summarizes essential system features to include MANPRINT requirements (Appendix E, AR 71-9), and performance characteristics.
- Trade Off Determination -- The TOD establishes viable trade offs for the suggested approach in pursuing the development program. It includes life cycle costing and scheduling information. ILS and MANPRINT requirements are included in issues which must be addressed within the TOD. OWL predictions regarding one or more trade off alternatives may be required.
- Trade Off Analysis -- TOA is prepared jointly by the combat developer and material developer. TOA serves to select the best technical approach based on the alternatives presented in the trade off determination. Again, MANPRINT and ILS requirements are essential trade offs. OWL predictions which consider system impacts resulting from OWL considerations may be important in completing the TOA.
- Best Technical Approach -- BTA is prepared jointly by the materiel and combat developer. It documents the BTA to include ILS and MANPRINT concepts based on the results of the TOD and TOA. The results of previous OWL predictions are considered in formalizing the BTA.
- Cost and Operational Effectiveness Analysis -- The COEA is prepared by the combat developer. It examines the cost and operational effectiveness of competing alternatives. All important systems aspects should be considered in addressing COEA to include OWL. OWL predictions and the results of OWL evaluations on bread board and brass board prototypes can provide important information.
- Bread Board/Brass Board Tests -- Bread board and brass board prototypes are normally fabricated and tested during the course of concept evaluation . Early OWL evaluations against these prototypes will provide an important baseline for future OWL predictions and the development of future OWL evaluation methodology.
- Acquisition Strategy -- The AS is the basic program plan for the development program. It is prepared by the material developer in coordination with the other members of the acquisition team. It provides guidance on tailoring the acquisition process for the specific

development and highlights potential risks and plans to reduce or eliminate risks. MANPRINT is specifically addressed in the AS (AR 70-1, paragraph 5-2b). OWL is an issue to be considered under MANPRINT analyses.

- System Safety Program Plan -- Safety and health hazard assessment issues have been addressed and identified for further resolution during the development process. These measures are addressed in the SSPP. Potential OWL issues may result from predictive analyses. OWL evaluation may result from bread board and brass board prototype tests. Considerations may include operational constraints, training requirements and restrictions.

- Integrated Logistics Support -- Integrated logistics support planning is initiated. This includes issues such as maintenance planning, manpower and personnel requirements, training operating personnel, and requirements for training devices. ILSPs prepared during the concept formulations phase may include the results of investigations based on performance data from deployed systems.

- Training Plans -- Training plans developed during the concept exploration phase address alternative training concepts. They are designed to highlight critical training areas for consideration during the balance of the development process, therefore contributing to the ultimate system availability, maintainability, and operational capability. Human factors considerations in general, and OWL considerations in particular are important training planning drivers. OWL predictions based on OWL evaluations of early bread board and brass board, and similar systems currently in the field are important sources of data for the preparation of training plans. These plans include assessment of appropriate training methods, media, training devices, skill qualification, evaluation procedures, and the need for training simulations.

- System MANPRINT Management Plan -- The SMMP is the management document that describes MANPRINT concerns and tasks and analyses that need to be conducted during the acquisition to ensure consideration of manpower, personnel, training, human factors engineering, system safety, and health hazard assessment. These issues are addressed and resolved or identified for resolution during following phases. OWL assessments of existing hardware may be useful in comparative analyses. The SMMP is initiated and maintained by the combat or training developer and is updated throughout the acquisition process (AR 602-2). (See Section 2.4.3 for further discussion of the SMMP).

- Test and Evaluation Master Plan -- Test and Evaluation Master Plan (TEMP) developed during the concept formulation provides the foundation for development and operational testing throughout the balance of the program. The TEMP provides the frame work for showcasing critical development and operational issues which need to be addressed during future testing. Operational issues which may be addressed during development testing, and the expansion of the development test data base during operational testing are important issues for consideration within the TEMP. Critical OWL issues (such

as those identified in the SMMP) are highlighted in conjunction with other MANPRINT and human factors related test issues.

- System Engineering Management Plan -- The System Engineering Management Plan (SEMP) is prepared in accordance with AMC Regulation 70-52. The SEMP will provide a framework for the integration of system requirements including MANPRINT and OWL considerations Application of sound system engineering principles, based on the SEMP, will be a required feature throughout the life of the program.
- System Concept Paper -- The SCP summarizes the activity of the Concept Exploration Phase and is the basis for obtaining approval to proceed to the next phase of development. Although the SCP is very brief, not exceeding 12 pages, it is a key document in the Materiel Acquisition Decision Process (MADP). OWL issues would not normally be expected to be highlighted within the SCP. However, critical OWL issues may be highlighted under the MANPRINT or HFE paragraphs in the Acquisition Strategy (Annex F).

Programs in the Concept Explanation phase may be under a program manager, may continue to be managed by the SSG/STF, or may be managed by an acquisition team appointed by the developing agency. TRADOC will typically follow the program through an appropriate TRADOC Systems Manager (TSM) with input from the Combat Development and Training Development Directorates of the proponent school.

#### 2.3.2.4 Demonstration and Validation Phase ( AR 70-1, AR 70-10, AMC Reg 70-52, Pam 70-2 , AR 602-2)

The Demonstration and Validation Phase is conducted to verify preliminary designs and engineering, and to accomplish the necessary planning and trade offs to reduce risks in future development and fielding. ILS and MANPRINT issues are addressed early-on (AR 70-1, paragraph 3-5a). Emphasis includes conducting trade offs among system characteristics, manpower, personnel, training, and support concepts. Other important tasks include preparation of the Required Operational Capability documentation and training device requirements. User participation is important during testing in order to prove out the O&O concept. OWL concepts and considerations are applied throughout this phase of development. It is essential to thoroughly apply OWL evaluation capabilities during this phase in order to insure that OWL related trade offs are thoroughly understood. The cost of modifying designs for the sake of OWL enhancements becomes progressively more expensive as the program proceeds to full scale development.

The demonstration and validation phase features procurement of advanced development prototypes for testing during development and operational tests . Frequently, competing prototypes will be developed, fabricated, and tested. The advanced development prototypes are designed based on functional requirements and are consistent with the Best Technical Approach articulated in the Concept Formulation Package. Technical and operational tests provide an excellent forum for validating OWL predictions made during the Concept Formulation Phase. It is important to ensure that OWL issues are addressed during these tests in order to develop a clear understanding of OWL issues which need be addressed in future development and production. Typical advanced development activities are described briefly with comments on their relationship to operator workload issues. These activities include:

- Advance Development Contract -- Advanced development prototypes are based on the preferred alternatives studied during concept formulation. Frequently, two or more competing prototypes will be procured for development and operational test and evaluation. OWL specialists should be involved in developing the technical data package for the Advanced Development Contracts and in evaluating the resulting proposals. The advanced development prototypes provide an efficient form for addressing the impacts and potential solutions to OWL problems in fielded items. OWL related designs features, OWL studies, and OWL evaluations may be all addressed within the frame work of the Advanced Development Contracts.
- Technical and Operational Tests -- Technical and Operational tests are conducted on advanced development prototypes and address critical issues established in the TEMP. Both government and contractor developed test data is used to address these issues. OWL specialists participate in or closely follow the conduct of these tests. In those cases where specific OWL issues are being evaluated within those test programs, OWL specialists will develop test procedures, collect or supervise collection of OWL related data, and report and evaluate the results of those tests. Frequently the developer and user address respective critical issues during the same test procedures. Close coordination with all individuals on the test team will enhance the efficient and effective collection of OWL related data. Established OWL evaluation methodology, or specific methodology developed during previous development phases, will be applied during technical and operational tests.
- ILSP Updates -- The ILSP, prepared during the Concept Formulation Phase, receives a complete update during demonstration and validation. This update is based on the results of testing. The updated ILSP examines support planning concepts, establishes a baseline support concept, identifies support parameters, and examines potential supportability problems. Logistic systems and resource constraints, and recommended reliability and maintainability parameters, are formulated.

- Training Support Planning Update -- The plans for training support are updated by the trainer and the material developer in coordination with the combat developer and logistician. This update is done in conjunction with preparation of the tentative qualitative and quantitative personnel requirements information (TQQPRI) which has significant OWL impact. The plans for training support will include plans for new equipment training. Training support plans establish the baseline for future training during full scale development, initial production and fielding, and subsequent support of the system in the field. Potential or identified OWL problems may be addressed through training.

- Tentative Qualitative and Quantitative Personnel Requirements Inventory -- The TQQPRI is prepared by the material developer. The TQQPRI is based on human factors studies, logistics support analysis, development of a system training strategy, and behavioral research. It describes personnel duties, tasks down to work units, performance standards, the basis for manpower authorization factors, recommended Military Occupational Specialties (MOS) to include skill levels, and recommended organizations. The TQQPRI, in conjunction with the Integrated Logistics Support Plans, are essential in developing hardware basis of issue plans (BOIP), training device requirements, and other training in support issues. The TQQPRI provides the most current information concerning numbers and qualifications of personnel required for employment support and maintenance of the system.

- Tentative Basis of Issue Plan -- The TBOIP is prepared by the combat developer in consideration of studies conducted by the combat developer and the TQQPRI. It serves as the basis for future development of how the system will be distributed and supported within the Army. The TBOIP is developed on the basis of the best available information.

- Training Device Requirement -- TDR requirements are developed by the trainer in conjunction with development of training support plans and the TQQPRI. Training devices used during testing and future tests may also be useful tools in investigating OWL issues.

- Required Operational Capability -- The ROC establishes essential operational, RAM, technical, personnel and manpower, training, safety and health, human factors engineering, logistical, and cost information. It is used as a basis for proceeding with full-scale development. Letter Requirements (LRs) are prepared for similar purpose for low dollar value items. MANPRINT issues are addressed in a specific section (Paragraph 8) of the ROC. Operational trainability and the technical feasibility of the proposed system is also addressed. OWL inputs to a ROC (or a LR) are based on the results of previous OWL evaluations and current OWL predictions. The most appropriate location for OWL inputs would be in the MANPRINT section.

- Safety and Health Hazard Assessment -- The Safety and Health Hazard Assessment is developed based on test results and other demonstration and validation phase activities. Results of OWL evaluations conducted during tests and potential OWL problems may be used in updating the Safety and Health Hazard Assessment.

- Human Factors Engineering Analysis -- The HFEA is conducted to identify any human factors problems associated with the system. Suitability of the system to proceed to the Full Scale Development Phase is established. Human factors issues, including OWL for resolution are highlighted.
- System MANPRINT Management Plan -- The SMMP is updated based on demonstration and validation phase results. Plans for future MANPRINT related activity are incorporated.
- Technical Data Package -- The technical data package (TDP) for a full-scale engineering development is a detailed specification for engineering development prototypes. The specifications must be in sufficient detail to insure delivery of hardware and software which is characteristic of that which may be delivered from production processes. Such detailed specifications may be useful in determining hardware design characteristics that impact OWL.
- Acquisition Strategy Update -- The AS developed during the Concept Formulation Phase is updated to support full-scale engineering development and subsequent production and fielding. MANPRINT issues, examined during the development of the original AS are re-examined, updated, and expanded. The results of OWL evaluations conducted during the validation phase and current OWL predictions are used as a basis for preparing OWL related inputs to the AS.
- Test and Evaluation Master Plan Update -- The TEMP is updated to reflect test and evaluation requirements for full-scale development, and production and fielding. OWL critical issues to be addressed during technical and operational testing and subsequent production related testing must be articulated in this TEMP update. OWL critical issues are based on OWL evaluation results from the tests and predictions made during the validation phase.
- Cost and Effectiveness Analysis -- COEA is updated based on the results of tests and studies conducted during the demonstration/validation phase. The resolution of OWL issues may have substantial impacts on COEA results. The results of OWL evaluations conducted during the validation phase and current OWL predictions are used as a basis for the COEA update.
- System Engineering Management Plan -- System Engineering activities continue in order to insure integration of required system features on a total system basis. The SEMP is updated to support full-scale development. These activities are a major tool for integrating MANPRINT in general and OWL considerations into the development program.
- Decision Coordinating Paper -- The DCP summarizes the results of the demonstration/validation phase, and provides a recommendation for proceeding with development of the system. It is a key document in the MADP for obtaining a decision to proceed to FSD. The DCP is not to exceed eighteen pages, excluding six annexes. The DCP includes a description of the alternatives considered during the demonstration/validation phase, and a description of the selected alternative to include the operational concept for the selected alternative.

Sustainability and economy of manpower are issues to be included in that discussion. The DCP also includes technological risks for the selected alternative and how those risks have been resolved in the demonstration/validation phase. OWL inputs to the DCP are based on OWL evaluations conducted during the demonstration/validation phase and current OWL predictions. The DCP includes the AS (Annex F) and its attendant MANPRINT/Human Factors section.

The Demonstration and Validation Phase is managed by a Project Manager, or by an acquisition team appointed from within the developing agency. DoD major programs and DAP will be conducted under a DOD or DA chartered Program Manager. TRADOC will typically continue to follow the major systems through an appropriate TRADOC Systems Manager (TSM) with input from the Combat Developments Directorate of the proponent school. IPR programs which are not under project or product managers will be managed by an acquisition team appointed by the developing agency.

2.3.2.5 Full-Scale Development (AR 70-1, AR 70-10, AMC Reg 70-52, Pam70-2 )

Full Scale Development provides an opportunity to completely evaluate the system in the form expected to be fielded. Systems which successfully complete full scale development are type classified as standard and are procured for issue to the field. The total system is normally prototyped, tested and evaluated, to include all support systems and software. These include simulators, training devices, computer equipment, training, and maintenance manuals. OWL evaluation expertise is required to ensure that OWL issues have been addressed in the full scale development prototypes.

There is limited opportunity to make changes in the system which will enhance OWL performance during this phase of development. Essential changes may be considered if there is a significant OWL problem. However, changes to any part of the system tend to cascade throughout the system, to include software and manuals. As a result, changes are expensive and time consuming. Most changes not demonstrated as essential for meeting system requirements would be considered during product improvement programs conducted after initial production and fielding. OWL inputs which have an impact on system design, therefore, are most effectively made prior to entry into this phase. Typical full scale development activities are described briefly with comments on their relationship to workload issues. These activities include:

- Full Scale Development Contract -- The full scale development contract is solicited on the basis of the technical data package developed during the validation phase. Full scale development prototypes are normally

typical in form and function of the expected production prototype. The contract also calls for evaluation and delivery of a complete suite of support equipment, to include test equipment, training devices, software, manuals, etc., as well as preparation of a technical data package for production. OWL related criteria should be one of the bases for evaluation of full scale development proposals.

- Technical and Operational Testing -- The complete system is tested and evaluated against criteria documented in the ROC or LR and developed in the TEMP. The Materiel Developer, and his contractor and technical tester (normally the US Army Test and Evaluation Command- TECOM) prepare and execute technical testing in accordance with the TEMP. The operational tester, either the Army Operational Test and Evaluation Agency (OTEA) ( for major systems) or a designated Training and Doctrine Command (TRADOC) school, address operational/user issues as specified in the TEMP. The resulting test reports are used to prepare technical and operational Independent Evaluations. Specialists develop tests, or make input into more general tests, in order to address OWL issues highlighted in the TEMP. OWL criteria which serve as a basis for accepting hardware or support equipment and software may be addressed in contractor testing for subsequent review by the government. OWL evaluation techniques are integrated as required into all testing.

- SMMP Update -- The SMMP is updated throughout the cycle to reflect analyses performed, questions and concerns addressed, new MANPRINT concerns that have been raised, as well as maintain an audit trail of all decisions and work that has been done in support of the SMMP.

- ILSP Update -- The updated ILSP is based on the ILSP prepared during the validation phase. The plan is expanded to address support of the system as it is introduced into the field. The ILSP is updated in concert with updates to the QQPRI, BOIP, incorporation into tables of organization and equipment (TOE), preparation of the Materiel Fielding Plan, and other ILS oriented actions. Test results and specific ILS studies are also used as a basis for the update. The results of OWL evaluations addressed during testing and other OWL studies provide OWL input.

- TEMP Update -- The TEMP is updated to support testing required during the production and deployment phase. Testing required to demonstrate that major deficiencies noted during technical and operational tests are corrected is described. Production validation tests and follow-on operational test and evaluation requirements are established. Requirements for first article and initial production tests are also established.

- AS Update -- The Acquisition Strategy is updated to emphasize production and deployment requirements. Critical OWL issues which remain to be addressed during the production and deployment phase may be presented as a MANPRINT consideration.

- Requirement Documents Revisions -- Revisions to the requirements document developed during the Demonstration and Validation Phase

(ROC, LR, TDR) must be considered to support production and deployment. Technical and operational characteristics may require revisions for a number of reasons including changes to the established threat. Any changes to the established requirement must be approved by both AMC and TRADOC and, in conjunction with the MADP, DA.

- Decision Coordinating Paper -- The DCP is prepared to support the production and deployment decision. It summarizes the results of full scale development and document recommendations for production and deployment. It includes a full description of the commitments the Army is making in proceeding with production, to include budget requirements and future support requirements. The revised Acquisition Strategy, with its required MANPRINT and human factors sections, is an annex to the DCP.

Typically, the same type of program management method is continued from that used in the Demonstration and Validation Phase. Development programs may be managed by a program or project manager, or by an acquisition management team appointed by the developing agency. TRADOC management is also normally continued with a TSM supported by combat development and training development elements. Programs which are project managed normally continue with that form of management, at least until the system is successfully fielded.

2.3.2.5 Production and Deployment (AR 70-1, Pam 70-2 )

During production and deployment operational quantities of the system and required support equipment is procured, personnel and operational units are trained, and the logistic support system is implemented to support the system in the field. If directed at the Milestone III decision point, Low Rate Initial Production may be implemented to address additional testing, production engineering or production base issues.

Follow-on Operational Test and Evaluation (FOTE) may be conducted during the production and deployment phase, if required, to address a spectrum of issues, including those with manpower and training impacts. FOTE has the potential to serve as relatively well controlled forum for developing OWL data upon which to base product improvement or new equipment requirement issues.

## 2.3.3 The Army Streamlined Acquisition Process ( AR 70-1 )

### 2.3.3.1 Overview

The Army Streamlined Acquisition Process (ASAP) compresses the standard acquisition cycle from over eleven years to seven years or less. The objective of the streamlined process is to achieve operational capability within the minimum practical amount of time, for low risk development programs. Programs which need more detailed and deliberate development processes, generally characterized as higher risk development programs, may still follow all or portions of the "traditional" acquisition process.

The streamlined process is characterized by four distinct phases as seen in Figure 2.3.3-1. They are 1) Requirements and Technical Base Activities, 2) Proof of Principle, 3) Development-Production Prove Out, and 4) Production and Deployment. Proof of Principle is followed by a go/no-go decision (Milestone I/II) to proceed into the development/prove out phase. The focus of the streamlined process is in the development/prove out phase. Activities typical of traditional full-scale development and early production/deployment are conducted as expeditiously as practical. Development/prove out is followed by a Milestone III decision point in order to provide approval to enter full production and deployment. The objective of the streamlined process is to achieve a Milestone III decision in fours years or less from demonstration of proof of principle. Overlaid on the streamlined acquisition procedure are provisions for preplanned product improvements (P3I) throughout the life of the system. New or improved technology is "inserted" at appropriate points throughout the life cycle as the threat or the technology changes. These insertion points may be during the development/prove out stage, as well as during the production and deployment phase or later in the cycle.

Documentation prepared during the conduct of programs under the streamlined acquisition process is similar to that prepared under the traditional process. OWL considerations for analysis and the development of design approaches and documentation are identical in comparison to those conducted during the traditional process. Successive iterations of documentation, as the system proceeds through the stages of development under the traditional process, are eliminated. OWL considerations for the development of specific documentation under the streamlined process will not be repeated here. Figure 2.3.3-1 illustrates how OWL considerations should enter the ASAP; these are identical to

## OWL IN THE STREAMLINED LIFE CYCLE

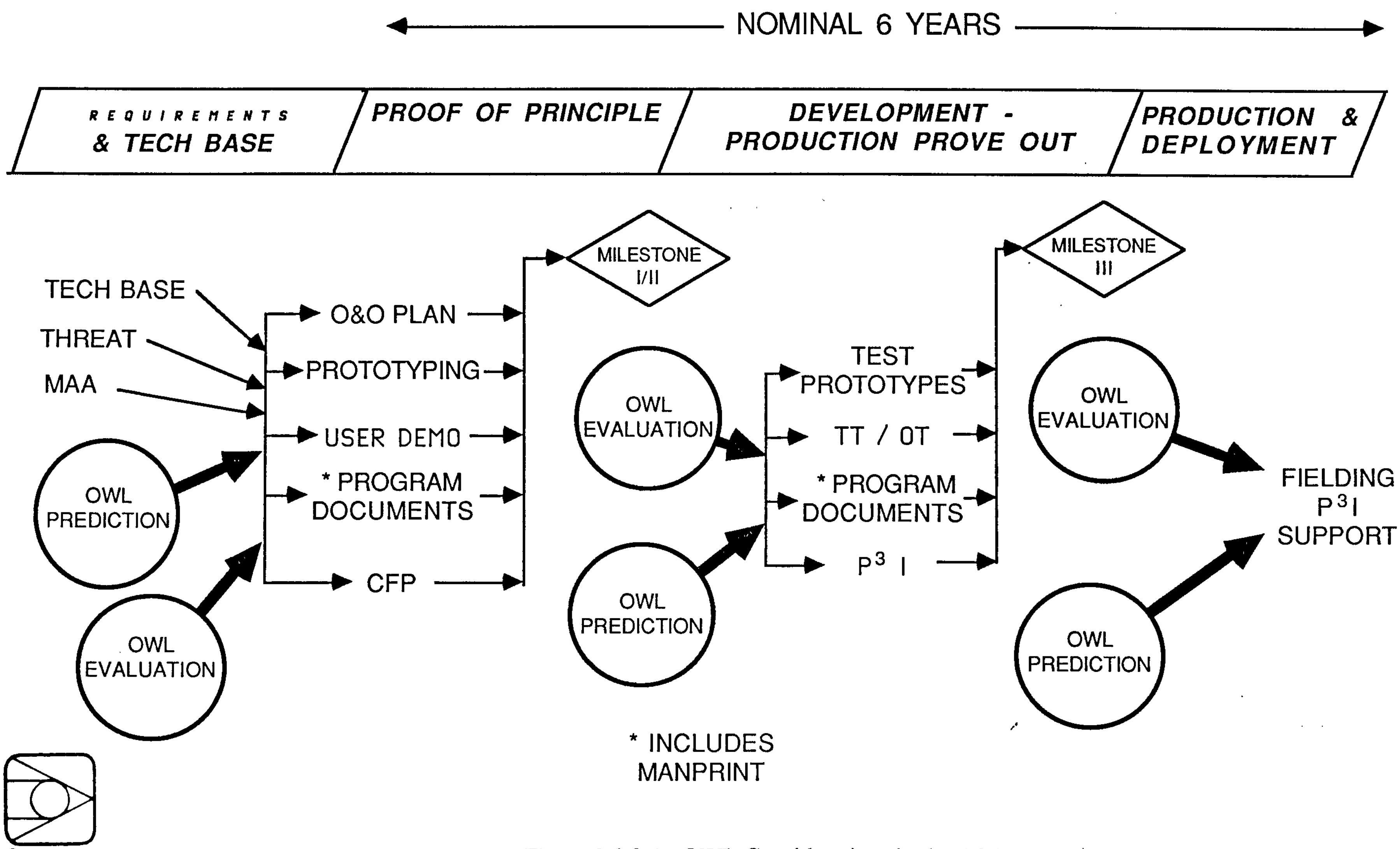


Figure 2.3.3-1 OWL Considerations in the ASAP

those in the traditional process. It is important to emphasize that as the process is compressed, so too are the opportunities for and impacts of OWL consideration. The most important phase of development under the Streamlined Acquisition Process in considering OWL inputs is Proof of Principle. Incorporation of OWL enhancements will be much more cost effective and efficient during and immediately after the proof of principle phase, in comparison to later in the Streamlined Acquisition Process. A brief description of each phase under the streamlined process, with emphases on OWL considerations, is presented below.

#### 2.3.3.2 Discussion of ASAP Phases

The first phase is the Requirements Definition/Technical Base Activities. Activities conducted during this phase are similar to the program initiation activities under the traditional process. They ultimately result in development of a JMSNS, or, as a minimum, an O&O Plan, and result in approval to proceed into the proof of principle phase. Basic program management documents such as the Acquisition Strategy, Acquisition Plan, SMMP and Test and Evaluation Master Plan may also be prepared during this phase. OWL considerations may drive requirements, as well as the accomplishment of technical base activities, such as research programs focused on OWL issues. OWL predictions, and the results of OWL evaluations of fielded systems which may address similar mission requirements, will impact the TEMP, SMMP, O&O Plan, and AS.

The ASAP calls for establishing a Technology Integration Steering Committee (TISC), with the objective of comparing technological opportunities with emerging requirements (AR 70-1, Paragraph 7-2c(2)). OWL considerations need to be considered by the TISC. TISC activities ultimately develop solutions which are suitable for consideration in hardware under proof of principle. Additionally, "Star" Reviews provide visibility and focus at the general officer level at the start of proof of principle. OWL considerations, based on related technical base activities, are issues for consideration by the TISC and during Star Review.

The second phase is Proof of Principle. Proof of principle consolidates activities conducted during concept exploration and demonstration/validation under the traditional process. The phase permits the conduct of user demonstrations and experimentation employing brassboard or surrogate systems in order to prove out the technical approach and operational concept. Proof of principle results in a "go/no-go" decision to proceed into

the development/prove out phase. Documentation supporting that decision (Milestone I/II) includes the CFP, TEMP, ILSP, and AS. MANPRINT and ILS issues are addressed on the basis of troop demonstrations and experimentation (AR 70-1, Paragraph 7-2f(3)).

Development of OWL requirements, and conduct of studies and analyses related to establishing OWL impacts, must receive strong emphasis during proof of principle. OWL evaluations of surrogate systems and brassboard prototypes serve as the basis for developing OWL requirements as a system enters the development/prove out phase. OWL predictions, based on systems currently in the field, will also make an important contribution to understanding OWL impacts. As with the early phases of the traditional MAP, OWL considerations will have their most cost effective impacts during proof of principle. Likewise, design features oriented to enhancing OWL characteristics must be identified during this phase. There will be little opportunity for modifying designs in order to enhance OWL characteristics during the development and prove out phase, except under the provision for preplanned product improvements (P3I).

The third phase is the Development/Production Prove Out phase. The development/production prove out phase encompasses activities which are similar to full-scale development under the traditional process. System characteristics are demonstrated using hard tool prototypes during technical and operational testing. Particular emphasis is placed on ILS, MANPRINT (AR 70-1, Paragraph 7-2g), and producibility engineering and planning. Documentation, and OWL considerations to be made during the preparation of that documentation, is similar to that required for full-scale development under the traditional process. OWL predictions and the results of OWL evaluations are sources of OWL data used in preparing that documentation. OWL evaluation methodology is employed during testing in order to demonstrate that prototypes meet required OWL characteristics.

Throughout this phase, requirements for P3I technology insertions are considered. Product improvements may be made during finalization of development/production prove out designs, or may be delayed until further into the production/deployment phase. OWL enhancements are more likely to be incorporated in a system which has entered the production/deployment or the development/prove out phases as P3Is. Based on a Milestone III review successful conduct of the development/production prove out phase results in both type classifying equipment as standard, and entering the production/deployment phase.

The final phase is the Production/Deployment Phase. The production/deployment phase includes low rate initial production (LRIP), first article testing (FAT), new equipment training, and initial fielding activities. Full rate production is achieved as initial fielding is completed and production models are demonstrated to achieve required capabilities. Documentation required under the streamlined process is similar to that required for the production/deployment phase. Generally, schedules for production/deployment under the streamlined process are compressed to one and a half to two years. OWL evaluation methodology may be used to demonstrate that production prototypes meet required OWL characteristics. OWL evaluations of fielded hardware may result in development of requirements for product improvement as production/deployment is completed. These requirements normally would be incorporated as a part of the overall P3I program for the system.

### 2.3.4 Adoption of Non-Developmental Items (NDI)

NDI is a candidate for fulfilling any material need. NDI include commercially available items, as well as items adopted by other services or friendly foreign nations. NDIs are considered in conjunction with market investigations accomplished early in the development cycle. If pursuing an NDI appears to be an acquisition alternative, a program to procure, test, and adopt the item is developed. There are two general categories of NDI (AR 70-1, Paragraph 7-3d):

- Category A -- Off the shelf items which need no further development or modification in order to achieve the required operational capability. These items would be expected to be used in a military environment under the same conditions for which they were intended in commercial environment.
- Category B -- Off the shelf items requiring modification to hardware designs or software in order to operate in the military environment. These modifications are typically required to ruggedize the item or enhance system survivability.

Acquisition Strategies for further development and fielding of NDI consider modifications needed and the requirements to demonstrate and prove the suitability of the equipment for military use. Adoption of an NDI does not eliminate the need to examine essential characteristics to include MANPRINT, systems safety, and logistic support concepts.

Conduct of NDI procurement programs are tailored to the requirement and the availability of suitable commercial or foreign equipment. NDI items which require considerable ruggedization with other modifications may drive establishing a program with features and requirements similar to a hardware development program. Sufficient testing must be conducted to prove operational, maintenance, and support characteristics. The features of the program are developed on the basis of the market analysis conducted prior to Milestone I.

ILS and MANPRINT issues vary from procurement to procurement. They are driven by the requirement and the characteristics of the commercial item and the Army's needs. The range of solutions varies from full acceptance of the commercial item, as taken "from the shelf" with a full commitment to future contractor maintenance and training support, to incorporation of the items into the Army training and logistic support system, and all combinations in between. All acceptable commercially available data is procured and utilized for system support.

The NDI program is tailored, based on the item characteristics and support available, to insure all requirements are met. For programs which need hardware modifications and/or development of training and support capabilities, the AS may be very similar to ASAP of a full system. The AS must address MANPRINT and ILS issues and resolutions must survive the MADP before adoption of an NDI.

### 2.3.5 Product Improvements (AR 70-1, AR 70-15, Pam 70-2)

Product improvement is a preferred method for responding to materiel requirements. They may range from modifications to a fielded item as a result of a Product Improvement Program (PIP) to planned evolutionary changes to a system in development (P3I). A PIP is distinguished from a P3I in that a PIP applies to systems which are already fielded and are no longer in production. Product improvements are an appropriate method of responding to workload deficiencies which are revealed late in the development cycle or in fielded systems. PIPs and P3Is are prioritized and integrated into the overall Army RDA program in the LRRDAP (see paragraph 2.3.2.2).

Product improvements may be applied to systems for a variety of reasons. For a PIP, these include: requirements to enhance human factors, safety or other MANPRINT

related system characteristics; improve system technical characteristics and operational effectiveness.as well as expand weapon system effective life. Preplanned Product Improvements (P3I) are required to be addressed in the requirements document for all developmental systems. They may be pursued to: reduce development time; reduce development risks; permit a timely response to changing threats; as well as respond to emerging technological opportunities. P3Is are also appropriate during system development to incorporate enhancements to: system performance characteristics and operational effectiveness; safety; human factors; and other MANPRINT requirements.

PIPs may be initiated by the materiel developer, the combat developer or field elements. The combat developer validates the need which precipitates the product improvement requirement. A Product Improvement Proposal is prepared and coordinated by the materiel developer. The Product Improvement Proposal fully documents the need for improvement and plans for development and application of the modifications. It includes an acquisition strategy and plans for developer and user testing to demonstrate the efficacy of the modifications. Detailed PIP procedures are established in AR 70-15. The PIP ultimately produces a DA Modification Work Order (DAMWO), Depot Maintenance Work Request (DMWR) or other approach to applying the modification and documenting it in the system technical data package.

P3I encourages an evolutionary approach to system design. That evolution is described in the acquisition strategy for the P3I program which are pursued in three phases:

- Phase I establishes how the system needs to evolve throughout the life cycle in order to respond to future operational requirements and technological opportunities.
- Phase II incorporates the results of Phase I into the basic system design.
- Phase III applies the modifications as block (i.e., several system changes) or individual changes.

Systems which have entered production and fielding must also make provision for the modification of systems already in the field.

## 2.4 OWL Issues in the Acquisition Process

### 2.4.1 How OWL Issues are Currently Addressed

One of the main objectives of the document review was to determine if and how operator workload issues (either physical or mental) were currently addressed as part of the Army MAP. Not surprisingly, there is not much specific discussion or guidance given in the regulations. There are more citations when the review is expanded to include mention and guidance concerning areas related to "workload issues" (e.g., human factors engineering, manpower, personnel, or other topic or term that considers soldiers as well as hardware). However, the connection and implications regarding OWL is more tenuous. This section addresses the specific references to workload that were found in the documents reviewed. The manner in which related topics are addressed in documents is also discussed in a more general context of OWL.

Documents from DoD, DA and subordinate organizations were identified. Within each document, other documents are listed (as required publications) which are necessary for complete understanding and implementation. In addition, there are also reference or related publications which may contain useful information but are not essential for complete understanding. By comparing the lists of required and related publications, a "document tree" may be established as graphically displayed in Figure 2.4.1-1. In this "tree", AR 70-1 may be seen to be the key Army acquisition document. It is associated with other ARs describing aspects of the acquisition process and with DoD high level guidance for military system acquisition. AR 70-1 also requires more technically oriented ARs such as AR 602-1 and 602-2. With regard to OWL, the most explicit reference to operator workload in Army-wide documents is contained in MIL-H-46855 (cf., Section 2.4.1.2). There are specific Data Item Descriptions associated with this military specification and, in turn, this military specification is directly related to the Human Factors Engineering AR. This indicates that these "workload"-related DIDs are only referenced via the HFE AR 602-1. The relationship shown in this document tree could be kept in mind during the more thorough discussion of the ARs, DoD guidance, and other related documents which follows.

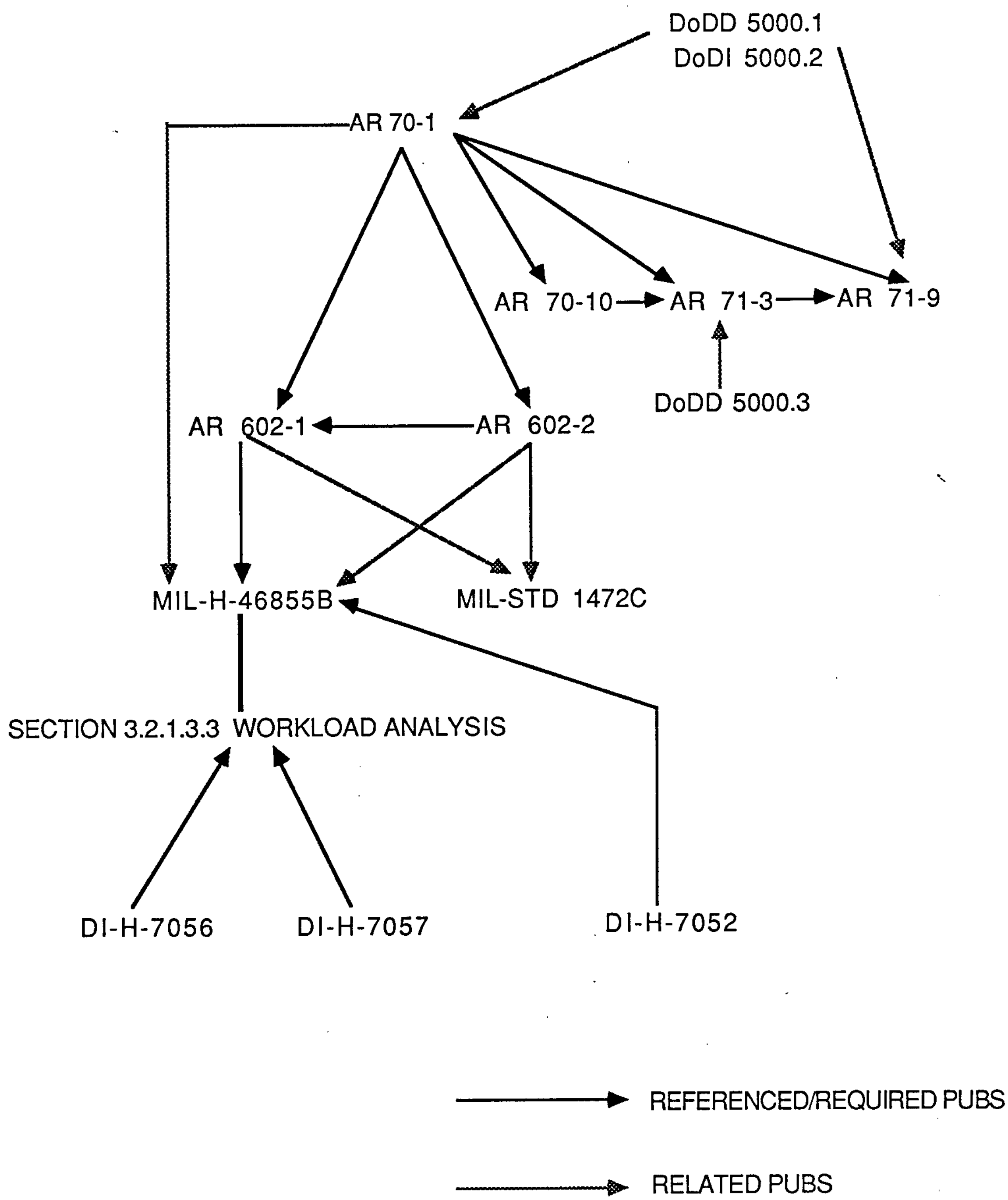


Figure 2.4.1-1. OWL- Related Relationship Between Primary Documents.

### 2.4.1.1 Army Regulations

A review of Army Regulations (ARs) was undertaken to identify those that govern system acquisition and any requirements for operator workload considerations as described earlier. The key documents identified are listed in Table 2.4.1-1. Of these, the first two (AR 70-1, -10) are in the Research and Development series. The next two (AR 71-3, -9) are in the Force Development series. ARs 602-1 and -2 are in the Soldier-Materiel Systems series. These regulations represent basic policy, guidance, and required formats in these three areas.

Table 2.4.1-1 Key Army Regulations

| AR | Title | Effective Date |
|---|---|---|
| AR 70-1 | System Acquisition Policy and Procedures. | 1 Dec 86. |
| AR 70-10 | Test and Evaluation | 30 Apr 86. |
| AR 71-3 | User Testing | 1 Mar 86. |
| AR 71-9 | Materiel Objectives and Requirements | 20 Mar 87. |
| AR 602-1 | Human Factors Engineering Program | 15 Feb 83. |
| AR 602-2 | Manpower and Personnel Integration (MANPRINT) in Materiel Acquisition Process | 18 May 87. |

A brief summary of these ARs indicates the major content and intention of each:

- AR 70-1 covers basic policies and procedures for Army system acquisition and "emphasizes front-end planning and tailoring of the materiel acquisition process..." (p. 3). The ASAP is introduced and its policies and procedures described.
- AR 70-10 covers basic policies and procedures for test and evaluation and provides information concerning test and evaluation for use at decision reviews.
- AR 71-3 covers policies and assigns responsibilities for user test and evaluation and continuous comprehensive evaluation (C2E) in the MAP.

- AR 71-9 covers policies and procedures and assigns responsibilities for preparing requirements documents for materiel and gives guidance for the combat development process within the MAP.
- AR 602-1 integrates human factors engineering throughout the MAP.
- AR 602-2 covers policies and procedures for the MANPRINT Program and establishes the requirement for the System MANPRINT Management Plan (SMMP). MANPRINT is an umbrella concept that encompasses HFE, manpower, personnel, training, health hazard assessment, and system safety.

These six documents do not specifically address OWL. Army Regulation 70-1 does, however, establish the policies, procedures and requirements for all applicable Army system acquisition programs. It calls out both AR 602-1 and 602-2, and specifies MANPRINT inputs into the different phases of the traditional Life Cycle System Management Model (LCSMM). Additionally, it specifies that MANPRINT considerations must be included in tailored acquisition programs (e.g., ASAP and NDI) and materiel improvements [i.e., Engineering Change Proposals (ECP), Product Improvement Proposals (PIP), or Preplanned Product Improvements (P3I)]. Specifically, it provides that "No acquisition . . . is exempt from minimal essential test and evaluation necessary to verify the MANPRINT . . . characteristics of a system . . . unless previous test and performance data or market analysis (information) is adequate for verifying operational effectiveness and suitability of the system" (p. 27). Sections 3-8 and 3-9 of AR 602-2 also define MANPRINT requirements for NDI and product improvements. In fact, MANPRINT concerns alone can provide the justification for a product improvement. MANPRINT considerations are clearly related to OWL.

While not specific to OWL, higher level documentation calls out HFE requirements in all phases of the acquisition process. AR 602-1 specifies HFE requirements throughout the materiel life cycle and stipulates that the HFE program shall be performed in accordance with MIL-H-46855B, thereby indirectly establishing the requirement that OWL issues need be addressed. Also, program objectives such as to ". . . Insure, through basic and applied studies and research in HFE . . . that equipment designs and operational concepts are compatible with the capabilities and limitations of operators and maintenance personnel" (p. 1-4) additionally point toward addressing workload issues.

In concert with AR 602-1 is the Army's new regulation for the implementation of its MANPRINT concept, AR 602-2. As it may be recalled, MANPRINT is an umbrella concept that encompasses HFE, manpower, personnel, training, health hazard assessment,

and system safety. As such, it (AR 602-2) assumes the responsibility for coordinating the requirements of its constituent domains. Thus, MANPRINT policy provides that HFE Analysis will be prepared in accordance with AR 602-1 on all Army major, designated acquisition, and in-process review (IPR) programs. Also, like AR 602-1, AR 602-2 addresses the concept of workload without specifically using the term [e.g., " . . . Analyses of the work environment also includes consideration of the physical and cognitive demands on personnel . . ." (p. 3), and " . . . Ensure through studies and analyses and basic and applied research (human factors engineering, . . . ) that equipment designs and operational concepts are compatible with the limits of operators and maintainers defined in the target audience descriptions . . . " (p. 3-4)]. Thus, specification of MANPRINT analysis requirements is equivalent to specifying HFE and OWL analysis requirements within the appropriate problem domain. This is important because higher level documentation, such as AR 70-1 tends to address issues and requirements more generically as MANPRINT issues and requirements. This leaves the relevant lower level documents to spell these out the details for the six application areas of MANPRINT.

This review altogether lead to the conclusion that attention to OWL concerns is currently required for all Army materiel acquisition programs. In part, this conclusion is not immediately obvious because at upper levels of acquisition process requirements, the OWL issues are subsumed under the more general requirements for MANPRINT/HFE. Also coupled with this is the fact that until recently, with the advent of programs like MANPRINT, HFE issues have not always received their proper attention. This may be especially true for operator workload analysis which have not been as well developed as other more traditional analyses of HFE.

#### 2.4.1.2 Military Specification MIL-H-46855B and Associated Data Item Descriptions

The purpose of Military Specification MIL-H-46855B is to establish and define requirements for applying human engineering to the development and acquisition of military systems, equipment, and facilities. The human engineering effort consists of analysis, design and development, and test and evaluation. An outline of the detailed requirements are given in Table 2.4.1-2.

Table 2.4.1-2 Outline of MIL-H-46855B Requirements

3. REQUIREMENTS
    3.1 General Requirements
        3.1.1a Analysis
        3.1.1b Design and Development
        3.1.1c Test and Evaluation
        3.1.2 Human Engineering Program Planning
        3.1.3 Nonduplication
    3.2 Detail Requirements
        3.2.1 Analysis
            3.2.1.1 Defining and Allocating System Functions
                3.2.1.1.1 Information Flow and Processing Analysis
                3.2.1.1.2 Estimates of Potential Operator/Maintainer Processing Capabilities
                3.2.1.1.3 Allocation of Functions
            3.2.1.2 Equipment Selection
            3.2.1.3 Analysis of Tasks
                3.2.1.3.1 Gross Analysis of Tasks
                3.2.1.3.2 Analysis of Critical Tasks
                3.2.1.3.3 Workload Analysis
                3.2.1.3.4 Concurrence and Availability
            3.2.1.4 Preliminary System and Subsystem Design
        3.2.2 Human Engineering in Equipment Detail Design
            3.2.2.1 Studies, Experiments and Laboratory Tests
                3.2.2.1.1 Mockups and Models
                3.2.2.1.2 Dynamic Simulation
            3.2.2.2 Equipment Detail Design Drawings
            3.2.2.3 Work Environment, Crew Stations and Facilities Design
            3.2.2.4 Human Engineering in Performance and Design Specifications
            3.2.2.5 Equipment Procedure Development
        3.2.3 Human Engineering in Test and Evaluation
            3.2.3.1 Planning
            3.2.3.2 Implementation
            3.2.3.3 Failure Analysis
        3.2.4 Cognizance and Coordination

The analysis section deals primarily with task analysis, function allocation, and estimates of potential operator/maintainer processing capabilities. Specifically, it provides:

> "3.2.1.3.3 Workload Analysis - Individual and crew workload analysis shall be performed and compared with performance criteria."

However, no further information is given as to how to perform such an analysis nor what performance criteria should be used. This specific reference for OWL analysis consequently comes under the domain of Human Factors Engineering (HFE). This military specification contains in its appendix an application matrix that gives guidelines as to what sections of the specification should be applied during what phases of the life cycle as well as what modifications should be made depending on the life cycle phase. The MIL-H-46855B appendix shows that specific workload analysis provision is in effect in all phases of the life cycle.

Data item description (DID) describes data and prescribes preparation instructions for the data for the analyses called out by MIL-H-46855. The series of DIDs on human factors engineering call for a wide range of information -- the DIDs are listed in Table 2.4.1-3. The specific DIDs that contain the requirements for implementation of this section are DI-H-7056, Human Engineering Design Approach Document - Operator (HEDAD-O), and DI-H-7057, Human Engineering Design Approach Document - Maintainer. DI-H-7052, Human Engineering Dynamic Simulation Plan, while not referencing Section 3.2.1.3.3, does contain the specific provision for the use of dynamic simulation for workload analysis. Of particular interest is DI-H-7056 because of its specific application to operators. Basically, the operator-equipment interfaces and the task analyses results are to be presented in the HEDAD-O.

#### 2.4.1.3 Aeronautical Design Standard-30

The Aeronautical Design Standard for Human Engineering Requirements for Measurement of Operator Workload (ADS-30) was the only Army document found that dealt specifically with OWL. The proponent is the U.S. Army Aviation Systems Command, St. Louis, MO. ADS-30 "establishes the requirement for a comprehensive, broadly-based workload assessment" to identify workload "chokepoints" in materiel systems (i.e., Army aviation systems). This standard provides for the workload assessment to be carried out throughout the design and development portions of the

Table 2.4.1-3 Human Factors Engineering Data Item Descriptions

| Number | Title |
|---|---|
| DI-H-7051 | Human Engineering Program Plan |
| DI-H-7052 | Human Engineering Dynamic Simulation Plan |
| DI-H-7053 | Human Engineering Test Plan |
| DI-H-7054 | Human Engineering System Analysis Report |
| DI-H-7055 | Critical Task Analysis Report |
| DI-H-7056 | Human Engineering Design Approach Document--Operator |
| DI-H-7057 | Human Engineering Design Approach Document--Maintainer |
| DI-H-7058 | Human Engineering Test Report |
| DI-H-7059 | Human Engineering Progress Report |

acquisition process. Types of OWL techniques are discussed and management methods for assessment by contractors are discussed.

#### 2.4.1.4 Department of Defense Documents

Three Department of Defense (DoD) level documents pertaining to system acquisition were reviewed for guidance regarding OWL. (These are listed in Table 2.4.1-4.) DoD Directive (DoDD) 5000.1, the first of these, presents DoD acquisition policy for major systems or major modifications to existing systems. Broad guidance for technical issues is included in the list of acquisition management principles and objectives. The most applicable principle to OWL issues is that improved readiness and sustainability are primary objectives, with operational suitability of equal importance to operational effectiveness. Operational effectiveness is the overall degree of mission accomplishment of the system.

Operational suitability is the degree to which the system can be placed satisfactorily in field use, with consideration given to availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistic supportability and training requirements. Operational suitability includes the ability of the soldier to operate, maintain and support the system, which would include OWL.

Table 2.4.1-4 Department of Defense Documents

| Document | | Subject | Date |
|---|---|---|---|
| DoD Directive | 5000.1 | Major Systems Acquisitions. | 12 Mar 86. |
| DoD Instruction | 5000.2 | Major System Acquisition Procedures | 12 Mar 86. |
| DoD Directive | 5000.3 | Test and Evaluation | 12 Mar 86. |

DoD Instruction (DoDI) 5000.2 describes the procedures to implement DoDD 5000.1. Workload issues are never specifically addressed, but might become topic areas included in a program review or in the program documents used in support of DoD level decisions. DoDD 5000.3 provides policy and guidance for test and evaluation in DoD and provides guidance for the TEMP. Again, specific issues are not addressed in this directive, although "use of properly validated analysis, modeling and simulation is strongly encouraged, especially during early development phases..." (p. 3). An important aspect of testing and evaluation is addressing critical issues that have been identified or may arise throughout the MAP. The DoD Directives (5000.1-5000.3) do not address specific OWL but provide high level policy that operational suitability is important and test and evaluation should address important issues.

### 2.4.1.5 Other Sources

Table 2.4.1-5 lists several further Army sources which that address OWL. The MIL-STD 1472C, the first of these, is the basic military standard for human engineering design criteria. The general requirements for equipment design include the principle "Design shall be such that operator workload, accuracy, time constraint, mental processing and communication requirements do not exceed operator capabilities" (p. 13). Similarly, software is to be designed to minimize task complexity and memorization. Operator response times will be with operational task limits (p. 242). The term "workload" appears in one other place; on p. 63, it is stated that the "distribution of work load" should be such that none of the operator limbs are overburdened. This is workload in the functional allocation sense. Interestingly, "workload" does not appear in the index. MIL-STD-1472C is a basic document where designers might look for information, but does not provide any information or suggestions specifically addressing OWL (with the few exceptions noted above).

Two sources were provided to us by individuals at TECOM. The TECOM Pamphlet 602-1 (Vol. 1), in particular, describes how to design subjective opinion tests and was identified by those individuals as "what was used to assess workload in technical tests." The second source was the Test Operating Procedure (TOP) 1-2-610 which provides detailed design criteria against which to test equipment. One of the procedures included is a Workload Assessment (p. 131) which suggests a time-line analysis and supplementing these observations with subjective questions. A Workload Assessment form is included with headings such as critical task, time required, additional tasks conducted simultaneously, effects of time delays in task completion, overload problems and underload problems. This is addressing "workload" in the context of sharing or consolidating the tasks to be accomplished.

Table 2.4.1-5 Other Army OWL Sources

| Document | Title | Date |
|---|---|---|
| MIL-STD-1472C | | |
| | Human Engineering Design Criteria for Military Systems, Equipment and Facilities | 2 May 81 |
| ADS-30 | Human Engineering Requirements for Measurements of Operator Workload | 17 Nov 86 |
| TECOM Pam 602-1 | | |
| (Vol I) | Questionnaire and Interview Design (Subjective Testing Techniques) | 25 Jul 75 |
| TOP 1-2-610 | Human Factors Engineering Data Guide for Evaluation (HEDGE) | 20 Nov 83 |

Several documents originally identified as relevant were unavailable for the present review because they are under revision or out of stock at the document distribution center. The documents include:

- MIL-HDBK-759 "Human Factors Engineering Design for Army Materiel"
- AR 10-41 "Organization and Functions, U.S. Army Training and Doctrine Command"
- AR 15-14 "Systems Acquisition Review Council Procedures
- MIL-STD-1388-1/2 "Logistic Support Analysis"/"Logistic Support Analysis Record"

Efforts to obtain and review these particular documents as well as identify, obtain and review other relevant documents to enhance our understanding of OWL requirements will continue. It is , however, believed that the present review has essentially revealed the status of OWL in the Army MAP.

### 2.4.2 Terminology

The term "workload" carries a multitude of meanings within the military community. For example, HARDMAN-type manpower, personnel and training (MPT) analyses specify workload and workload analysis for system operators and maintainers. Within this context, however, workload is defined as the number, frequency and durations of activity-based tasks, performed by a specific number of personnel of particular MOS's, skill levels and paygrades. The output of workload analyses are numbers and grade qualifications of personnel necessary to operate and/or maintain a system. This performance/manhour based interpretation is much more restricted than that which is taken here or that is necessary to fully address OWL issues. Within other contexts, it is clear that workload does not refer to cognitive/physical underload or overload, but rather to task-based manning considerations. It seems, then, that care must be taken to clearly discuss exactly what is being discussed when using terms like "workload" and "workload analysis". Certainly, manpower considerations are closely tied to potential "cognitive overload" (see section 2.4.3), but they are different and should be clearly differentiated. Care must also be taken, as intended here, when addressing a military audience to insure that the proper framework for discussing perceptual, cognitive, psychomotor workload, is established up front.

### 2.4.3 MANPRINT

The Army Manpower and Personnel Integration (MANPRINT) initiative focuses on the soldier-in-the-loop and front-end analysis in the acquisition process. As noted earlier, MANPRINT seeks to integrate six areas that are concerned with the soldier into the materiel acquisition process so that soldier needs and abilities are considered early in the process. The six areas, called domains, are Manpower, Personnel, Training, Human Engineering, Health Hazards Assessment, and System Safety.

#### 2.4.3.1 Interrelationships between OWL and the Domains

Manpower, personnel and training (MPT) are critical areas in the Army MAP. Manpower is concerned with force structure and deals with how many people and of what Military Occupational Speciality (MOS) are needed to operate, maintain, and support materiel. These are sometimes referred to as the "spaces." Personnel issues deal with the

kind of people needed to operate, maintain, and support materiel. People in this context are recognized as possessing different levels of intelligence and skill, as well as different personality attributes. Personnel issues are sometimes referred to as the "faces", implying the individual characteristics of the soldier. Training, of course, is the instruction of the soldier in specific skills and procedures needed to perform necessary tasks. Training is done in schools and in units and many methodologies are used. Each of these areas must be addressed in the development of Army requirements and are not synonymous with OWL. However, there are interrelationships between OWL and MPT that should be kept in mind as this effort proceeds.

One relationship between manpower and OWL is the term "workload" (as discussed in Section 2.4.2). For many tasks, it is not inappropriate to conclude that if there is too much for one person to do in a certain amount of time to specific criteria levels, then having two people do the job will take care of the problem. However, this relatively simple addition of more people (assuming that the additional people with the needed abilities are available) will not solve every problem. The process of perceiving and processing must ultimately rest on single operators in many circumstances. Adding another person in this case would not help.

The distinction between between manpower and OWL concerns may be made by questioning (1) whether the task(s) that are creating the "workload" are of the kind that can solved by just adding another person or (2) is the nature of the task such that it must be done by an individual and it requires too much in too short a time period.

Personnel issues are concerned with the individual characteristics of the soldiers. The interrelationship between OWL and personnel issues involve such areas as the trade offs between intelligence and "quality" as identified by the ASVAB (i.e., mental categories I-IV) and the degree of soldier perceptual, cognitive, or psychomotor loading. Trade offs may need to be identified depending on the types of soldiers available because of this interaction of personnel characteristics and system design.

Training is another area with which OWL is interrelated. Increased training gives the soldier knowledge, skills, and practice in the required tasks. Additional training may be and is frequently treated as <u>the</u> solution to overcome inadequate performance. However, training often may not be effective in reducing workload, or a cost effective way of and enhancing performance (Hart, 1986). In order to adequately control the more cognitive

workload, there may need to be trade offs made between training and the quality of soldier chosen as the operator. Another alternative is to affect the hardware design as part of HFE.

Human Factors Engineering (HFE) is concerned with the engineering design of equipment and the soldier-machine interface so that system performance (including the human element) is maximized. OWL issues are interrelated with HFE in the design of the equipment, specifically the soldier-machine interface design. If an interface has been designed well, the ease with which the operator can perceive information or perform motor tasks may be optimal, thereby reducing workload. An unthoughtful and poorly designed interface may be the major factor in creating a workload intensive task. Human factors engineering solutions should certainly be among the first pursued when overload problems are identified.

Health hazard assessment (HHA) is concerned with any condition inherent to the use of equipment that may cause degradation of job performance, chronic disability or death. Health hazards include toxic substances, vibration, noise, temperature extremes and psychological stressors. Although this last area is not universally considered a health hazard, psychological stressors, such as confined spaces, isolation, sleep deprivation, and sensory/cognitive overload, may cause serious degradation or chronic disability in job performance. There is currently no overall Army program addressing these psychological stressors from a HHA perspective. However, health hazard assessors try to identify potential problems early in the acquisition process and raise a flag that this issue must be considered as the MAP continues (LTC B. Leibrecht, USAARL, personal communication, 30 April 1987). OWL should be an issue from the HHA perspective in the acquisition process.

System safety (SS) is concerned with identifying and eliminating or reducing the risks associated with system (particularly hardware) characteristics that may cause injury or death. The results of hardware failure (e.g., electrical shorts or restraint harnesses breaking) are of particular concern. OWL issues are related to the safety of the system only and to the extent these risks intrude and occupy the operator.

It can be concluded from the above discussions that operator workload is related to all six areas of MANPRINT. It is not clearly synonymous with, nor falls under the specific purview of, any particular domain. However, the interrelationships between OWL and the MANPRINT domains are important considerations in developing system

requirements and design. Considerations of these interrelationships will identify MPT, HFE, HHA or SS trade-offs that may be made in an effort to control OWL as system requirements and design are defined.

As specified by the Army in its training courses on MANPRINT, there are several tools to be employed by the six MANPRINT domains. Among these is workload analysis, which the Army indicates is to be used during all phases of the acquisition process to answer such questions as:

- Which design alternative is the best?
- What training will be required?
- Can operators perform all functions effectively?
- What design inadequacies exist that must be rectified?

These questions as well as others are raised during the various phases of the acquisition process as appropriate, and workload estimation and measurement techniques must be developed that can provide timely answers.

#### 2.4.3.2 System MANPRINT Management Plan

The System MANPRINT Management Plan (SMMP) is the "planning and management guide and an audit trail to identify tasks, analyses, trade-offs, and decisions that must be made to address MANPRINT issues during the materiel development and acquisition process" (AR 602-2, p. 12).

The SMMP is initiated very early in the acquisition process by the combat or training developer and requires consideration of concerns and questions that may affect soldier performance in Army equipment. This is an appropriate and logical place to include OWL concerns and has the important attribute of being initiated at the very outset of materiel requirements development. The SMMP is to be started prior to the program initiation, and most likely will be developed concurrently with the O & O Plan. Even at this point, OWL concerns can be raised and methods to answer questions and address concerns can be suggested.

The format for the SMMP is given in Appendix B of AR 602-2. The five major sections include:

- a summary of MANPRINT strategy

- a description of the proposed system, with the acquisition strategy, agencies involved and any existing guidance also described
- a description of the MANPRINT strategy including the objectives, data source availability, and planned MANPRINT analyses
- any issues or areas of concern which have been identified
- the tabs, which include list of data sources, MANPRINT milestone schedule, task description, questions to be resolved, and list of all organizations with which the SMMP must be coordinated.

Although the regulation requiring the SMMP is new (17 April 1987), some guidance is available through the SMMP Procedural Guide (1986). It is expected that as more experience is gained by those who prepare the SMMP, the SMMPs will increasingly address issues in the MANPRINT areas and provide a useful management plan to control factors such as OWL.

The SMMP has several sections which provide opportunities to address OWL concerns early and throughout the MAP. In particular, the Concerns section (paragraph 4) is the place to discuss any identified issues in the system development. These concerns are those that should be monitored throughout the MAP. Further, the Questions to be Resolved (Tab D) are the detailed questions that need to be answered to address the concerns identified in Paragraph 4. These questions should be detailed and specific. In some ways, development of the Tab D questions will lead to the analyses that need to be done in order to obtain sufficient information to answer the questions (these analyses are to be presented as part of Paragraph 3b as well as the identification of predecessor or reference systems and what kind of data is expected to be available for use). Tab A is also identified as the place to list all potential data sources in all the MANPRINT domains and should also include those relevant to OWL. A description of the tasks to be done in support of MANPRINT efforts are to be presented in Tab C. These descriptions include the rationale, resources needed, time to complete, and responsible agencies.

Clearly, if an awareness of and sensitivity to OWL issues can be developed by those preparing the SMMPs, then their format should provide the means to surface broad concerns about workload issues and well as the specific questions that need to be investigated in order to adequately address the stated concerns. The identification of predecessor system and data list will directly affect the types of OWL predictive and/or evaluative assessments that can be conducted. Similarly, it will affect the timeliness with which such assessment can be performed in the sense that well-documented data sources and known availability will facilitate its gathering and application.

Any key OWL issues or concerns should also be included in the summary (Paragraph 1) which presents an overview of MANPRINT. The summary will be the portion most often read by decision makers and will give visibility to the key issues. The status of key issues can be monitored and managed as the SMMP is continually updated with current information.

Another aspect of the SMMP that is of interest in the control of OWL is the role of the MANPRINT Joint Working Group (MJWG). Although the SMMP is the responsibility of the Combat Developer (i.e., TRADOC), it is to be developed in conjunction with the Materiel Developer (i.e., AMC). The MANPRINT Joint Working Group (MJWG) is the group of people that work together to create the SMMP and includes representatives from the Combat Developer, the Materiel Developer, and other organizations that are involved. The SMMP should consequently have inputs from all interested organizations and they can play a part in the lists of concerns, questions, and tasks to be accomplished.

### 2.4.4 Identified Army Projects

During the document review, other procedures and analyses that have been developed for the Army and that may be useful in this effort were identified. As we continue our investigations, existing procedures or information that can be used in workload analyses will be utilized to the fullest extent possible. Some of the identified sources and the potential use in OWL assessment are delineated in the following.

#### 2.4.4.1 Early Comparability Analysis (ECA)

The Early Comparability Analysis (ECA) Procedural Guide (1986) summarized that "the ECA methodology is based on a 'lessons learned' approach to the design of a conceptual system" (p. 1). For ECA, a predecessor (or reference) system is identified with which to compare the conceptual system. Relevant MOSs are identified, task lists for those MOSs are obtained (or derived if not available). Subject Matter Experts (SMEs) are also consulted to assign "difficulty" ratings to tasks using six task criteria: percent performing, task learning difficulty, task performance difficulty, frequency rate, decay rate, and time to train. Those tasks costly in MPT resources are identified and solutions are proposed to eliminate or reduce the cost of these "high drivers."

ECA uses a combination of several analytic techniques to identify MPT resource-intensive tasks (comparison, SMEs, task analysis) . As discussed previously, MPT issues are interrelated with OWL issues and their treatment in the context of an analysis already in place can yield OWL information very early in the MAP. This could enhance the development of OWL analyses as ECA is designed for use by combat developers as an in-house tool, therefore it is not intended to be a highly sophisticated tool for use only by technical experts. OWL estimations have been previously made based upon comparability (e.g., Shaffer et al., 1986), SME (Zachary, 1980), and task analysis (e.g., Stone et al., 1985).

#### 2.4.4.2 Hardware vs. Manpower (HARDMAN)

The HARDMAN Comparability Analysis is a "structured approach to the determination of the Manpower, Personnel and Training (MPT) requirements of a weapon system in the earliest phases of its development" (Mannle, Guptill, and Risser, 1985). HARDMAN is primarily an MPT analysis and sophisticated comparison methodology is used to derive estimates for MPT. It does produce task analyses with time-lines that could be used for certain OWL estimation methodologies (e.g., Stone et al., 1985). However, HARDMAN is a sophisticated tool -- currently only one company performs the analyses for the Army -- and it is expensive to do. Therefore, HARDMAN will, most likely, not be available for use on all systems and may not be expected to provide a broad basis for predictive analyses of OWL.

#### 2.4.4.3 Logistic Support Analysis (LSA)

The Logistic Support Analysis (LSA), as described by AR 700-127, is performed to identify existing or proposed support structure and requirements, as well as apply Integrated Logistics Support (ILS) and MANPRINT influence in system design and selection. LSA is required in all acquisition programs. As part of the LSA, certain tasks are required of both the combat and materiel developers. Such tasks as use studies (Task 201), comparative analyses (Task 203), and task analyses (Task 401) are required in accordance with MIL-STD-1388. The LSAR may be a useful source of data for maintainer workload estimation and evaluation. Further investigation is needed to determine what data would actually be available for use for assessments of OWL.

2.4.4.4 Human Resources and Test Evaluation System (HRTES)

The Human Resources and Test Evaluation System (HRTES) (Kaplan, Crooks, Sanders and Dechter, 1984) is a set of procedures designed to assist a test planner to evaluate operator and maintainer performance in an operational test of an Army system. The HRTES procedure takes the test planner through a series of steps from general system issues to the highly specific human performance issues. For example, a set of considerations would be to 1) define mission performance 2) define performance conditions such as weather, 3) identify system performance issues and criteria and then 4) identify human tasks and performance criteria for each task. Interspersed through this analysis is the reminder of the need for planning and for identifying the techniques for measuring each of the criteria. The HRTES procedures have potential utility for OWL assessment with regard to identifying and defining system characteristics for use in the selection of individual techniques.

2.4.4.5 MANPRINT Data Base

A MANPRINT data base is currently under development at the U.S. Army Materiel Readiness Support Activity. The main purpose of the data base is to organize MPT, HFE, HHA and SS data for use in comparative analyses. The data base will contain historical data organized by end item. The MPT portion will contain such items as RAM data, MOSs related to the end item, manhours and tasks. The HFE, HHA, and SS area will be addressed in more of a "lessons learned" approach, with any problems being identified and solutions (if any) given. The plan is to have the programming of the data base on line by 4th Quarter, FY 88. However, it may be 2 or 3 years before the loading of the data is complete and the data base is accessible to outside users.

A key problem in the data base development is the availability of operator data. So far only the maintainer is fully documented, primarily because generic functions/subtasks are more easily defined for maintainers. It is much more difficult to define generic functions/subtasks for operators (Mr. G. Tarber, USAMRSA, personnel communication, 8 May 1987).

As the data base is further developed and becomes accessible, it may provide a good source of data for workload and comparability analyses. Currently, however, operators are not addressed and there is not a firm plan on how to do so.

### 2.4.4.6 Summary

These procedures have been identified as potential sources of information or data for use in OWL assessments. The descriptions of the procedures and how they may be used for OWL assessment are only preliminary judgments. Additional methods and procedures as well as application potentials may be expected to evolve because of the increasing interest in programmatic effort (e.g., MANPRINT).

## 2.4.5 Conclusions and Recommendations

A number of conclusions can be drawn from the document review. Some of these conclusions will have an impact on the future tasks of the OWL project in directing how the guidance for OWL assessment are written (i.e., the handbooks). The major conclusions and recommendations are:

- In general, there is a void in Army documents on the topic of OWL.
- OWL assessment is required (via MIL-H-46855), but indirectly through the areas of HFE and MANPRINT.
- There do not seem to be any inconsistencies regarding OWL, primarily because there isn't much available.
- The intent to consider the soldier in materiel acquisition is clear in high level DoD Directives.
- Clear distinctions between types of workload must be made.
- Effort should be made to make use of existing projects as much as is appropriate.
- ASAP, NDI and product improvement strategies will make early attention to OWL even more critical.
- MANPRINT provides a framework on which to build and provides places to address OWL issues (e.g. the ROC and the SMMP).
- The MANPRINT portion of the ROC is an appropriate place to address soldier-in-the-loop requirements (e.g., OWL) for the new equipment.
- The SMMP would be a useful vehicle to focus attention on potential OWL problems and devise plans to address OWL throughout the MAP.

The review of the documents provided a useful means to understand the current Army requirements and how issues concerning operator workload are addressed. The lack of specific guidance was not really surprising -- there has been greater awareness in recent times because of the technological advances being included in Army materiel. The identified lack emphasizes the timeliness and importance of the current OWL project effort.

# 3. ASSESS USER NEEDS

## 3.1 Introduction

In the effort to fully understand the Army MAP and how OWL issues are addressed, a review of written documents was conducted as described in Section 2 subsequent to beginning the interviews. A better understanding of the process and issues was obtained by talking to the people who are actually involved in the process. The purposes were to further our understanding of the Army MAP and learn how OWL is currently considered. These discussions provided the opportunity to identify the concerns of the Army community with respect to: workload (and related items they cared to share); what guidance or tools would be most helpful to them; and how things actually worked as opposed to the written descriptions that had been reviewed.

This section will describe our approach to obtaining information about Army user needs and will report the information obtained. With the exception of the information received via the questionnaires (see Section 3.4), the information presented has been obtained from discussions and has been integrated to reflect general concerns and suggestions, rather than identifying specific users and their comments. This section overviews: our approach; user concerns as expressed in discussions and questionnaires; user suggestions concerning the consideration of OWL during the MAP; as well as the handbooks to be produced during this contract effort. Finally, plans for follow-up assessment of user needs will be discussed.

## 3.2 Approach

### 3.2.1 Army Organizations Visited

The Army organizations with whom we spoke and the date(s) visited are presented in Table 3.2.1-1. In addition, the DoD HFE Test and Evaluation Technical Advisory Group was briefed on 7-8 Apr 87 at NASA-Langley, VA. Researchers at NASA-Langley also briefed us regarding their recent and continuing work in the area of mental-state estimation. Their work relates directly to workload assessment and will be included in our Task 3

Table 3.2.1-1 Army Organizations Visited

| Date | Organization |
|---|---|
| 1 Apr 87 | U.S. Army Materiel Command<br>Alexandria, VA |
| 1 Apr 87 | U.S. Army Soldier Support Center -- National Capitol Region<br>Alexandria, VA |
| 2 Apr 87 | U.S. Army Operational Test and Evaluation Agency<br>Falls Church, VA |
| 6 Apr 87 | Department of the Army Armored Family of Vehicles Task Force<br>Ft. Eustis, VA |
| 16 Apr 87 | U.S. Army Test and Evaluation Command<br>Aberdeen Proving Ground, MD |
| 21 Apr 87 | U.S. Army Aviation Systems Command<br>St. Louis, MO |
| 23 Apr 87 | U.S. Army Aviation Center<br>Ft. Rucker, AL |
| 5 May 87 | U.S. Army Armor School<br>Ft. Knox, KY |
| 6,7 May 87 | ARI Field Unit Representatives from Ft. Bliss and Ft. Huachuca<br>Ft. Bliss, TX |

review. Altogether, a wide range of approximately 120 individuals were contacted, including TRADOC, AMC, and other independent agencies.

### 3.2.2 Conduct of Discussions

Initial contact with the organizations was made by the COR and visit dates and times were arranged. Following introductions at the meeting site, a 25-minute briefing was given by a member of the Analytics team to introduce our effort and explain the purpose of the meeting. The briefing typically included:

- Introductory remarks
- What is OWL?
- The importance of OWL in the Army
- OWL program objectives
- Our approach: user inputs; matching model; handbooks
- Candidate System Selection Criteria

Upon completion of the briefing (or during as appropriate), the floor was opened for questions and comments. The discussions focused on whether OWL is considered in their organization; if so, how it is considered; what guidance and tools are needed; and any suggestions for the products (handbook outlines). The second focus of discussion was on any emerging systems that the participants were aware of that would be good candidates for validation of operator workload measures. The selection of systems is later described in Section 5.

### 3.2.3 Questionnaire Distribution

Questionnaires and handbook outlines were distributed at the conclusion of each meeting. Participants were asked to distribute them to appropriate individuals within their organization and return the completed questionnaires to Analytics. A sample questionnaire is included in Appendix A. (The handbook outlines are discussed in Section 4.).

## 3.3 Army Community Concerns

### 3.3.1 What is OWL?

A common point of discussion in the meetings held was what exactly operator workload implied. There seemed to be an understanding of the problem of increasing technology and decreasing personnel resources causing increased cognitive operating requirements. However, there does appear to be uncertainty about the meaning of the term " workload." The diverse concerns included:

- Is workload based on the number of tasks to be performed?
- Does the workload issue revolve around the scarcity of Cat I (i.e., high ability) soldiers and the necessity of using Cat IVs? How do MOSs relate?
- Is workload physical , mental or both?
- How is maintainer workload related to operator workload?
- How does workload relate to MANPRINT? Is it the same as MANPRINT?

### 3.3.2 Organizational Concerns

The Materiel Acquisition Process consists of many organizations (both government and contractor) performing a series of sequential steps to achieve the goal of fielding effective and suitable equipment to accomplish a mission. The sequential nature of the process assumes the previous steps have been adequately accomplished in order for the next steps to be performed. As a result of the nature of the MAP, many comments expressed in our discussions were concerned with collection and use of the system-relevant information that has been produced previously in the MAP. A second major area of concern was resources. The resources include the people to do the required work, the expertise needed to do the work, the time in which to accomplish the work, and the money with which to pay for it. Both of the major areas of concern can be summed up in the expression that was heard in both TRADOC and AMC organizations "TRADOC doesn't do its job up front, but AMC has all the money." This expresses the frustrations that: (1) many of the important decisions impacting performance and OWL (such as crew size and operational capability) are determined very early in the MAP (as in the requirements documents) but (2) TRADOC does not always have the resources or information to make

knowledgeable decisions during this period. These decisions and requirements are the ones that will subsequently drive the design and development of the system.

There seems to be a consensus that OWL is currently addressed in a reactive mode. Only after it has been identified as a problem, or potential problem, is any action taken. There is awareness that a continuous process of addressing OWL throughout the MAP would enable the players to control OWL in a proactive manner.

The people involved with specific systems (e.g. TRADOC System Managers (TSMs) and action officers in Program Manager shops) are aware of potential workload problems but don't have the guidance, the expertise, an approach, or the necessary financial resources to adequately address OWL. Increasingly, they are looking toward the U.S. Army Research Institute (ARI) and the U.S. Army Human Engineering Laboratory (HEL) for direction in areas concerning human performance. The MANPRINT officer is also seen as a resource for both human performance and OWL concerns, however, often the MANPRINT officer has not been on the job very long and does not have a great deal of experience. The systems people are looking for whatever help they can get, and often there is only one ARI or HEL resource person with more work than one person can realistically accomplish.

Specific comments were made concerning the Required Operational Capability (ROC). A concern, particularly of testers and evaluators, was that the ROC does not provide sufficient specifics concerning human performance upon which to base test and evaluation criteria. It is difficult for them to know if there is a workload problem, or a potential problem, when there are inadequate measures of effectiveness (MOEs) and no specified levels of performance in the ROC. Certainly there is some form of evaluative judgment involved in identifying potentially excessive workloads, but there is frustration in the latter portion of the MAP in the test and evaluation area. Those involved with evaluation particularly feel that a good job is not being done in thinking about the human performance issues in the front end of the MAP in casting the requirements documents.

A second comment on the ROC was that firm decisions regarding crew size (i.e., reduced crew size) are being included, apparently without front-end analysis being done that would give information concerning the reduced crew capability. A comment made in one discussion suggested that the Army should design the capability of the equipment

around the capability of the crew (with its size, intellectual and physical abilities limitations) rather than fitting the crew to the operational wish-list of the equipment.

Another concern was that the data expected to exist do not always exist. Because of the resource constraints at the combat developer schools, such things as task lists and ECAs are not always developed in a timely way (if ever). Concern was raised that if any additional paperwork or analyses for OWL are required, that they probably wouldn't be done either. Some felt that no matter how useful and beneficial the analyses might be, there will be some resistance to doing them based on resource constraints as well as bureaucratic inertia.

### 3.3.3 Major OWL Needs

The major OWL needs identified from our meetings with Army personnel are the following:

- The need for OWL assessment techniques that will provide pertinent OWL information so that ROCs will provide a better framework for all subsequent system design work as it relates to human performance considerations.
- The need for OWL assessment techniques that are not heavily dependent upon extensive resources and expertise.
- The need for an OWL overview pamphlet that orients Army personnel to the concept, its importance, its relationship to MANPRINT, who should be concerned about it and when.

### 3.3.4 Projected Needs

When the discussions turned to anticipated or projected needs concerning assessment of operator workload, there were two basic categories mentioned. The first was the new emphasis on ASAP and NDI as the acquisition strategies of choice. The streamlined process basically requires the quality of development work to be done in a more compressed time frame. Therefore, it will be even more critical that the requirements are well conceived and front-end analyses are done so that the development can be expedited without running into design problems. The NDI strategy presents new problems in that the only opportunity to ask questions or obtain data is in the market survey process. There will be no opportunity for testing until after an initial purchase. Within the market

survey, information can be requested from vendors, but there is no assurance that the vendor has even thought about the workload issue or that any data pertaining to the issue will be available to the government. Perhaps, as soldier-in-the-loop performance issues become more important (e.g., through emphasis on MANPRINT), such issues and how they have been handled by the vendors will be seen as selling points.

MANPRINT was also seen as a driver in anticipated needs for OWL assessment. The requirements for inclusion of MANPRINT in the ROC (AR 71-9), the required SMMP, and all the other efforts to institutionalize MANPRINT in the MAP are seen as driving new needs for data and analyses concerning soldier-in-the-loop. The needs are particularly seen early in the process in the analytical arena. However, TRADOC plans on doing more testing through its Force Development Test and Evaluation (FDTE) testing program. Early testing issues will become of more interest and importance.

### 3.3.5 Identified OWL Problems

Our meetings with Army personnel resulted in a common concern being voiced about OWL. That is, the potential for excessive cognitive/mental workload demands being placed on operators as a result of innovative software systems. These new software systems have automated many of the functions previously done by operators as well as provide functionality not previously possible (e.g., new information). As a result, operators' jobs have changed to being "managers of information" whereby the requirements placed on the operator are to manage and digest the information provided via software systems and make decisions based on such information. This concern for excessive cognitive/mental OWL was expressed, in general terms, without specific reference to existing systems per se but was foreseen as a problem with future developing systems and proposed improvements to systems. Section 5 in this report describes the prototype systems that have been identified as candidates for the OWL assessment phase of this project. We have selected prototype systems that are indicative of this general concern for OWL.

### 3.3.6 Other Workload Initiatives

The issue of OWL is being addressed on several different fronts by various groups. These include Army agencies that are addressing future design of system concepts (Army HEL Crew Reduction Modeling Study) as well as theoretical issues concerning OWL (Army HEL Stress Program). Also, NASA Langley Research Center at Langley, VA is exploring OWL in aviation systems by means of mental states estimation. We have made contact with these groups and have exchanged ideas concerning our effort as well as theirs. Below are brief descriptions of these programs objectives as well as their stage of progress.

We will continue to identify other OWL initiatives so to keep abreast of the latest developments in the field and evaluate the applicability of these initiatives to our program.

- Army HEL: Crew Reduction Modeling Study, Aberdeen Proving Ground, MD. HEL is the beginning stages of developing a computer-driven mathematical model to evaluate the feasibility, desirability, and effectiveness of reducing the size of combat vehicle crews (e.g., tanks). They are in the process of selecting an outside contractor for computer modeling of combat crew operation (Sept 87).
- Army HEL: Combat Stress Program, Aberdeen Proving Ground, MD. A multi-disciplinary research program has been started to provide basic human and weapon systems performance data under "combat-stress" conditions by means of modeling the battlefield conditions that soldiers are subjected to. This is a 4-phase program that is presently in Phase I. In Phase I, efforts are underway to determine which "stress indices" are likely to reflect the effects of acute exposure to stress (i.e., battlefield conditions) in test participants and are likely to work best in simulating such conditions in the laboratory.
- NASA Langley Research Center: Mental States Program, Langley, VA. NASA has just started a 5 year program whose initial objectives are to identify physiological indices that reflect "mental states" such as fatigue and boredom which have been shown to influence operator performance. Ultimately, these physiological signs will be monitored by sophisticated software systems during aircraft flights in order to identify the points in time when software intervention is needed for maintaining flight performance.

## 3.4 Questionnaire Results

Nineteen people have fully responded to the survey questionnaire to date. Though this is a relatively small sample, the data provide a basis for discussion concerning the

Army needs for guidance on OWL. A copy of the survey questionnaire can be found in Appendix A.

### 3.4.1 Demographics

Nine respondents were civilians who worked for Army organizations such as TRADOC, ARI and HEL while the remaining ten respondents were military personnel who performed various roles in the MAP, (e.g., TRADOC assistant system manager).

With respect to functional roles, eight respondents indicated they have MANPRINT responsibilities/functions that support TRADOC schools (n=2), TRADOC integrating centers (n=2), and test and evaluation agencies (n=4). The remaining eleven respondents were TRADOC project officers (n=2), TRADOC assistant system managers (n=2), and representatives from ARI (n=3), HEL (n=1) and TRADOC integrating centers (n=3).

The nineteen respondents as a group represent integral players in the MAP who can contribute toward addressing OWL during system development. The major organization not adequately represented in this sample was materiel developers (AMC). Our future plans are to include an adequate sample from AMC.

### 3.4.2 Operator Workload (OWL)

The questionnaire contained specific questions on the importance of OWL with respect to respondents' work (present and future), the means they use now to address OWL and future directions (guidance) needed to address OWL. The results were somewhat surprising.

When asked how often the issue of OWL should be considered in their work, a majority of respondents (n=13) stated "often" (based on a 4 choice category scale - "often", "sometimes", "rarely" or "never"). In addition, respondents foresaw a greater emphasis on addressing OWL in their work for several reasons. Almost all respondents (n=17) saw changes in requirements (i.e., MANPRINT) as a force in directing their future efforts toward addressing OWL. Also, a large majority (n=16) saw "changes in technology" with respect to system innovations as an important factor in directing their work efforts to addressing OWL. Based on such an overwhelming consensus that OWL is an important

issue to be addressed in their work, one would anticipate respondents would employ similar methodologies/tools to address workload; this was not the case. When respondents were asked to state the specific guidance (documents) they use to address OWL, eleven (11) people stated they have no source document for addressing OWL issues. The remaining eight (8) respondents gave assorted answers such as ECA, HARDMAN, OWL studies in journals, and operator task lists when available.

When respondents were asked how they would like to address OWL, answers varied between respondents. For example, some offered no suggestions (n=5). Other respondents stated that specific organizations should address OWL but not "my" organization (n=3). The remaining eleven respondents gave individual answers such as more resources devoted to OWL issues, better defined ROC documents with respect to human performance, videotaping operators performing task scenarios, task analysis, objective performance measures, and physiological measures.

When respondents were asked to state the guidance they would like to have for addressing OWL, several suggestions were offered. These were:

- Standardized methodology/tool for addressing OWL that requires minimal resources, it is non-intrusive, in real time and characterized as objective in nature (n=4)
- Training course on what OWL is and how to address it (n=2)
- Local points of contact (POC) for OWL (n=2)
- OWL Handbook for writing ROC documents (n=1)
- How to raise funds to address OWL (n=1).
- Preparation of a MIL-H-46855 Workload DID (n=1)

Based on these findings, it seems apparent that Army personnel are concerned about addressing OWL in their work, however, there seems to be a lack of uniform direction and understanding with regard to what OWL is, how to address it, and where might one find answers to these questions.

### 3.4.3 Respondents' Work Responsibilities during the MAP

The survey contained a series of questions to profile the work done by Army personnel as it relates to the MAP. Questions pertained to identifying major work

responsibilities, the inputs and outputs to such work as well as the sources of information used to accomplish this work.

Table 3.4.3-1 lists the major areas of responsibilities stated by respondents. Almost half of the respondents (n=9) indicated having several overlapping responsibilities during the MAP, (i.e., they responded to more than one category).

Table 3.4.3-1 Responsibilities/roles during the MAP that are held by respondents

| Responsibility/Role | Number of Respondents |
|---|---|
| Define or review requirements, standards, criteria | 10 |
| Develop or monitor the design of emerging system concepts | 8 |
| Design or monitor the characteristics of early prototype systems | 7 |
| Test & evaluation of systems (early, mid-term, late) | 7 |
| MANPRINT (R&D) | 2 |

As seen in Table 3.4.3-1, most respondents' responsibilities are centered in the early portions of the MAP. Their roles are seen as critical for identifying OWL issues early in the MAP such that OWL can be addressed in a proactive mode. This is further exemplified by the fact that the recipients of their work are integral players in the MAP. Table 3.4.3-2 shows the major organizations and functional roles who are the recipients of the work accomplished by the survey respondents. Some respondents indicated having several recipients of their work.

Table 3.4.3-2 The major organizations and functional roles who are the recipients of the work produced by survey respondents

| Organizations/Functional Roles | Number of Respondents |
|---|---|
| TRADOC Schools (e.g., combat developers) | 7 |
| Army Materiel Command (e.g., materiel developers) | 7 |
| Test & Evaluation Organizations (e.g., OTEA) | 5 |
| TRADOC Headquarters | 2 |

In summary, the respondent's responsibilities and their associated work are an integral part of the MAP and serve to direct all future work that occurs during system development. But, the respondents lack standard methodologies/tools to address OWL issues as seen by their answers to questions about OWL.

### 3.4.4 Sources for Information

With respect to fulfilling their job responsibilities, respondents listed the Army documents as well as agencies that they referred to or seek guidance. We were interested in identifying these sources in order to understand the types of information and guidance sought by respondents. Such information would provide insights to the work issues that respondents felt were important but lack the knowledge or experience to address these issues solely by themselves. Table 3.4.4-1 lists the major sources of such guidance. Most respondents used multiple sources.

Table 3.4.4-1 Major sources for information and guidance that are used by respondents to fulfill their job responsibilities

| Organizations | Number of Respondents |
|---|---|
| Army Research Institute (ARI) | 11 |
| Army Human Engineering Laboratory (HEL) | 7 |
| TRADOC Headquarters | 6 |
| TRADOC Schools (e.g., TRADOC system manager) | 4 |
| Directorate of Combat Development | 3 |
| Test & Evaluation Organizations (e.g., OTEA) | 2 |

| Documents | | Number of Respondents |
|---|---|---|
| DOD Directive 5000.3 | Test & Evaluation | 4 |
| AR 602-2 | MANPRINT | 11 |
| AR 70-10 | Test & Evaluation | 5 |
| AR 71-3 | User Testing | 4 |
| AR 71-9 | Materiel Objectives & Requirements | 4 |
| AR 70-8 | Personnel Performance & Training | 2 |
| MIL STD 1472-C | Human Engin. Design Criteria for Military Systems, Equipment, & Facilities | 3 |
| HARDMAN | (Hardware vs. Manpower Compar. Anal.) | 1 |
| ECA | (Early Comparability Analysis) | 1 |

Clearly, the respondents' sources for information (e.g., ARI, MANPRINT) reflect their concern to address human-related issues (i.e., human performance). It is of interest to note that the documentation sought for guidance contains minimal information on OWL.

### 3.4.5 Performance Issues with respect to the Total System Development Process

The survey contained a series of questions to ascertain the different performance areas that respondents consider in order to do their job. Table 3.4.5-1 summarizes participants' responses to four major performance areas. Listed are the number of respondents who responded to a 4-choice category scale ("often", "sometimes", "rarely", or "never") by checking the "often' category with respect to these performance areas. Table 3.4.5-2 summarizes participants' responses to major human performance areas. Listed are the number of respondents who responded to a 4-choice category scale ("often", "sometimes", "rarely", or "never") by checking the "often" category with respect to these performance areas.

Table 3.4.5-1 Number of respondents who stated that they "often" consider these performance issues in their work

| Performance Area | Number of Respondents |
|---|---|
| Total System Performance | 16 |
| Subsystem Performance | 10 |
| Operator Performance | 16 |
| Maintainer Performance | 13 |

Table 3.4.5-2 Number of respondents who stated that they "often" consider these human performance areas in their work

| Human Performance Area | Number of Respondents |
|---|---|
| Human Factors Engineering | 14 |
| Manpower | 11 |
| Personnel | 13 |
| Training: Individual soldiers | 16 |
| Training: Unit | 8 |
| Safety | 11 |
| Health Hazards | 10 |

It is quite evident from these results (Table 3.4.5-1, & Table 3.4.5-2) that performance issues (total system and human element areas) are given consideration by respondents.

### 3.4.6 Conclusions

The results of the study show that respondents are aware and concerned about human performance areas. However, a standardize methodology/tool as well as a single source for information addressing OWL is lacking. It also seems apparent that respondents' lack of clarity in their answers to specific questions about OWL (e.g., no responses) indicate a fuzziness on what is meant by OWL and how to address it. This finding is very revealing as the respondents to this survey have ideal positions from which to address OWL throughout the MAP.

## 3.5 User Suggestions for OWL Program in Army

Within the context of the discussions with users, a number of suggestions were given as to what the users thought would be most useful to Army users. Although most of the suggestions have already been touched upon, a separate listing was thought to be helpful. The items are not in any specific order. The suggestions are:

- Integrate with the MANPRINT effort to ensure success.

  It was recognized by many with whom we spoke that to assure implementation of any OWL guidance that was developed, some type of regulatory emphasis was needed. The most practical suggestion was that the MANPRINT requirements (e.g., SMMP) be used as the vehicles to address OWL concerns.

- Guidance must accommodate limited resources and expertise available.
- Make the cognitive/mental aspects of OWL the explicit focus of the project.
- Capitalize on any existing information or data that relates to OWL.

  Information is generated and analyses performed to make decisions in the current MAP. Before attempting to require more data and information generation, be sure to examine what is already available to see if it might be useful in answering OWL questions.

- Both TRADOC and AMC must be receptive to this effort. To get the most benefit, both must be involved in OWL assessment and control.

- Create an associated OWL DID.

  There is an awareness that contractors will be in the correct place to gather data relevant to OWL. In order to capture those data, as well as assuring that an appropriate methodology is being followed, create a Data Item Description so that there is a means to obtain data from the contractor during system design and development.

- Have awareness that contractors may be ones to use the developed OWL guidance.

  Early analyses that requires technical expertise or more man-hours that internally available may be contracted out. Similarly, the realization that the RFP is the most appropriate place to require OWL assessment.

## 3.6 User Suggestions for OWL Products

The users made several suggestions regarding the handbooks to be produced. The suggestions are:

- Computer-based mode of presentation.

  The users questioned the use of written material (i.e., handbooks). Their experience has been that there is a tendency to just put handbooks on a shelf and not use them. The suggestion was that guidance, particularly the predictive and evaluative handbooks, created on an on-line, interactive, computer-based system might be better and easier to use.

- Pamphlet should be used to institutionalize the concept of OWL.

  Many integral players in the MAP do not consider soldier-in-the-loop when developing system concepts and designs. The pamphlet may be useful to draw attention to the soldiers' performance aspects of system performance and to advise managers to raise flags when an OWL problem may be involved.

- Two recommendations should result from our guidance for selecting specific OWL techniques.

  Recommendations: 1) a minimum assessment battery for low-resource applications , and 2) a more complete battery of OWL techniques for circumstances where more resources are available.

## 3.7 Conclusions and Recommendations

Several conclusions can be drawn from the discussions that were held:

- Within the Army community, there is real concern about OWL but there seems to be lack of conformity in how to address it. Everyone seems to have their own way of doing it or ignoring it.
- There was skepticism of any project as wide-reaching (i.e., going across organizational boundaries) as this one.
- It is important for us to keep abreast of other Army initiatives concerning operator workload.
- Any program or methodology developed has to be sensitive to resource limitations.
- The methodology must be able to accommodate the ASAP, NDI, and other acquisition strategy procedures.

## 3.8 Follow-on Interview Plans

Those individuals in Army organizations with whom we spoke provided useful information. We will continue our discussions with them throughout the project as appropriate for later follow-ups. Current plans are to keep them apprised of the project progress and to consult with them again in the future concerning the handbooks. Since our primary goal is to provide useful information in the most appropriate format, the Army community of users will be consulted regarding the development of the handbooks.

# 4. OUTLINE OF FINAL PRODUCTS

## 4.1 INTRODUCTION

In the original statement of work (SOW), five major areas were identified to be addressed by a set of handbooks which Army personnel would use for making decisions on OWL during the materiel acquisition process (MAP). These areas were:

- How and where to use handbooks
- Guidelines for how to estimate OWL, including how to select the most appropriate measures of OWL for a given new system design
- Guidelines for evaluating OWL during concept and evaluation, and developmental and operational testing
- Alternative methods for reducing excessive OWL in Army systems, and
- Recommendations for selecting among or prioritizing those alternative OWL reduction methods.

These five major areas were originally proposed to be covered by three related products: an overview pamphlet for the TRADOC community on OWL, and two handbooks addressing OWL techniques, one to be used during the early phases of the MAP (pre-Milestone 1 activities) and the other to be used during system development phases of the MAP (post-Milestone 1 activities).

To ensure these products are successfully received by the Army community, we developed draft outlines depicting each product's content as well as descriptions of the rationale for each section covered. These outlines were used to elicit Army personnel comments and reactions in order to ascertain their specific needs concerning OWL and to "shape" the final handbook products. It was the first step in our ongoing and iterative development of user-oriented products. Examples of the draft outlines that were discussed in the interviews with Army personnel may be found in Appendices B through D.

Based on meetings with Army personnel, we identified two major concerns that needed to be addressed in all the OWL products to ensure their successful use and incorporation into the work activities of the intended users of these products.

- A thorough description of what operator workload is, the importance of OWL as a significant determinant of system performance, and how it relates to system requirements and design issues.

- A descriptive framework to show the integration between existing Army requirements (e.g., MANPRINT requirements) and other Army programs (e.g., HARDMAN) and the approach prescribed in the handbooks. How the OWL program complements and supports these existing Army programs.

Besides these overall considerations, each outline elicited specific comments and suggestions. These user reactions will be discussed in the respective subsections for each proposed product.

## 4.2 TRADOC PAMPHLET

### 4.2.1 Original Concept in Statement of Work (SOW)

The TRADOC overview pamphlet was originally conceived as a guide for TRADOC personnel "to incorporate workload in the ROC (Required Operational Capability)". This pamphlet was seen as an overview that described what is meant by OWL and how to address it in a ROC . It would highlight the issues of OWL such that TRADOC managers, (i.e., combat developers), could recognize the need to address OWL in ROC documents and assist them to make provisions (e.g., requirements) for its adequate assessments in subsequent phases of the MAP.

### 4.2.2 Rationale for Original Draft Outline and Revision

Our original draft outline expanded the scope of the pamphlet. We envisioned the pamphlet providing an overview emphasizing the need to address OWL throughout the MAP such that managers in TRADOC and AMC who are in positions to oversee the development of systems would have the proper framework to address OWL throughout the cycle. Otherwise, issues that relate to OWL could be overlooked as the MAP progresses. Such an emphasis on OWL throughout the MAP would provide the correct orientation for OWL to be addressed in a proactive mode as opposed to a reactive mode of fixing past mistakes attributed to excessive operator workload. The original pamphlet outline dated 9Feb87 is found in Appendix B.

Based on our discussions with Army personnel who are involved with various phases of the MAP, it became apparent that the pamphlet should go beyond our original

conceptualization with respect to our intended audience. That is, there seemed to be a lack of awareness and/or concern that OWL is an important issue to be addressed throughout the MAP.

As a result, the pamphlet needs to address OWL such that all integral players in the MAP (e.g., TRADOC, AMC, OTEA, AMSAA, and TECOM) are aware of the importance of addressing OWL throughout the MAP since all can contribute to preventing OWL problems. To do so required revising our initial pamphlet outline such that ALL key personnel in the MAP would be oriented to conceptualizing, developing and evaluating systems with OWL as a major consideration. This is especially true today since new technologies (automation via software innovations) and projected manpower reductions are placing a potentially heavier burden on operators to mentally perform new operations that can directly impact system performance. We have revised the manager's pamphlet outline to reflect this orientation toward OWL so ALL Army personnel involved in system development realize the coordinated effort needed across organizations to ensure that OWL is addressed in a proactive mode. The revised pamphlet outline dated 23May87 follows this subsection.

# REVISED MANAGER'S OPERATOR WORKLOAD ASSESSMENT PAMPHLET

## OUTLINE

USER PROFILE: The intended users for the pamphlet are the managers who are involved in both delineating the needs, and developing the requirements for a new system as well as those involved in evaluating system performance in which the soldier-in-the-loop is considered an integral part of the evaluation. This user is not interested in the details of workload estimation or evaluation. What IS of interest to these managers is high-level guidance on what are the Army requirements regarding workload, and what high-level provisions should be built into the system acquisition strategy for the assessment of OWL. The orientation of this pamphlet is to instill the concept of operator workload (OWL) in the everyday vocabulary of managers such that it is addressed in a proactive mode throughout the MAP. This can only happened if ALL managers, irrespective of organizations, are attuned to the importance of OWL as a major factor contributing to overall system performance. Each manager has a role in ensuring that OWL does not adversely affect overall system performance.

FORMAT: This Pamphlet will be structured to provide a concise, easily understood presentation of the role of OWL control in the materiel acquisition process (MAP). Tables, charts, flow diagrams, and specific examples will be used liberally to promote quick apprehension of concepts.

GOAL: Provide the reader with an overview of the role of OWL control in the materiel acquisition process, including the nature of the problem, DoD/DA documents and requirements concerning OWL control, and available technologies to assist ALL Army managers (e.g., TRADOC, AMC, OTEA, AMSAA, and TECOM) in ensuring OWL control. Provide guidance in accessing other OWL control resources, especially the OWL Prediction and Evaluation Handbooks.

LENGTH: approximately 40-50 pages

## I. INTRODUCTION

A. Definition of Operator Workload (OWL)

B. Traditional factors attributed to OWL, e.g., physical involvement of operators

C. New technologies affecting system concepts, e.g., automation via software

D. New factors attributed to OWL, e.g., mental/cognitive involvement of operators

E. Impact of OWL on Army Mission Functions

F. Army requirements, specifications, standards and regulations for OWL

G. Relationship of OWL to MANPRINT Program

H. Contribution of ALL managers involved with the MAP in addressing OWL

I. Description of the contents of this pamphlet, how to use this pamphlet

STRATEGY: Introduce managers to the key OWL concepts and regulations. Provide the proper framework on how to use this handbook.

## II. OVERVIEW OF OWL FUNDAMENTALS

A. OWL Performance Model - factors contributing to workload.

B. OWL with various types of actions/behaviors that are mental/cognitive in nature

1. Searching for and receiving information
2. Identifying objects, actions, events
3. Problem solving
4. Decision making

C. OWL considerations for system types with respect to Mission Areas

D. OWL considerations during the Materiel Acquisition Process (MAP)

1. Accelerated Systems Acquisition Process (ASAP)
2. Proactive mode vs. reactive mode in addressing OWL
3. Key questions concerning OWL to be addressed throughout the MAP

E. OWL Assessment Program

1. Prediction (analytic approach)
2. Evaluation (empirical approach)
3. Analysis of results - addressing key OWL questions as revealed by analysis of one's results/data

F. OWL Control Plan

STRATEGY: Provide a global "mental map" for the user on the key areas and steps involved in OWL prediction/evaluation and its relationship to the materiel acquisition process.

## III. OWL IN REQUIREMENTS ANALYSIS/CONCEPT FORMULATION

A. TRADOC perspective - combat developers

B. AMC perspective - program managers

C. Evaluators/testers perspective

D. OWL trade offs in concept formulation

E. Development of a preliminary OWL Control Plan

F. Key OWL resources

1. Documents
2. Organizations (e.g, HEL, ARI)
3. Individuals (e.g., HFE specialists)

G The TRADOC Manager's OWL Concept Formulation Check List

1. What should the TRADOC combat developer be ensuring is accomplished.

H. The AMC Manager's OWL Concept Formulation Check List

1. What should the AMC program manager be ensuring is accomplished.

STRATEGY: Provide the user a step-by-step approach to developing and managing an OWL Control Plan during requirements analysis and concept formulation. Provide the manager the knowledge to integrate the OWL Control Plan with existing requirements, programs, and other control plans that are part of the materiel acquisition process.

## IV. OWL IN SYSTEM DEVELOPMENT

A. TRADOC perspective - system managers

B. AMC perspective - program managers

C. Evaluators/testers perspective

D. The OWL Control Plan

E. Methods for assessment

1. OWL Prediction (analytic approach)
2. OWL Evaluation (empirical approach)

F. Key OWL resources

1. Documents
2. Organizations (e.g., HEL, ARI)
3. Individuals (e.g., HFE specialists)

G. TRADOC system manager's OWL Check List for OWL Prediction

H. TRADOC system manager's OWL Check List for OWL Evaluation

I. AMC program manager's OWL Check List for OWL Prediction

J. AMC program manager's OWL Check List for OWL Evaluation

K. Testers/Evaluators Check List for OWL Prediction

L. Testers/Evaluators Check List for OWL Evaluation

STRATEGY: Provide the manager a step-by-step approach to developing and managing an OWL Control Plan during system development. Provide the user the know-how to integrate the OWL Assessment Program with existing requirements, programs, and other control plans that are part of the materiel acquisition process.

## V. ITERATIVE NATURE OF OWL ASSESSMENT

A. Materiel acquisition process

B. System design decisions

C. Evolution of OWL considerations

STRATEGY: Establish the concept that the OWL Assessment Program and its management and control are evolving processes which are modified as the materiel acquisition process progresses and requires the coordination and cooperation of all Army agencies involved in the MAP.

## VI. OWL CONCERNS AND ARMY SYSTEM DEVELOPMENT ITEMS

A. Non-Developmental Items (NDI)

B. Product Improvements (P3I, PIP)

STRATEGY: Elaborate on the special circumstances these areas present for addressing OWL and emphasis the need to ensure that OWL does present itself as a problem.

## VII. EXAMPLE

A. An example will be provided that delineates the various managerial responsibilities across organizations that play a role in controlling OWL during the MAP - the development and implementation of their respective OWL Control Plans.

STRATEGY: Provide the user with a concrete example of an overall OWL Control Plan.

## VII. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

## 4.3 PREDICTION HANDBOOK

### 4.3.1 Original Concept in Statement of Work (SOW)

The Workload Prediction Handbook was originally conceived as a guide for addressing OWL during the new system concept development phase of the MAP (pre-Milestone I activities). The handbook would direct Army personnel in employing OWL predictive techniques by identifying the most appropriate predictive technique with respect to their particular needs and resources. The techniques offered would lend themselves to identifying OWL issues that need to explore and/or address in the further refinement of the system concept. Use of such techniques would give valuable direction early-on in the MAP so to minimize potential OWL problems in later phases of the MAP.

### 4.3.2 Rationale for Original Draft Outline and Revision

In general, our original draft outline attempted to provide a methodology for identifying the most appropriate predictive technique for a given system concept. It also highlighted the importance of OWL, its relationship to system performance and OWL evaluations conducted during later phases of the MAP. The original pamphlet outline dated 9Feb87 is to be found in Appendix C.

Based on our meetings with Army personnel, we identified sections in the outline that needed further clarification as well as new material to be included in the handbook. The predictive handbook needs to address and/or clarify the following:

- Greater emphasis on the significance of addressing OWL early-on in the MAP - greater likelihood of success, (i.e., incorporating OWL considerations in later design phases), as well as the most cost-effective point in time to offer suggestions for design changes (i.e., least expense involved in comparison to later phases of the MAP).
- The complementary relationship between the use of this handbook and the Army's new directive to address soldier issues early-on in the MAP - MANPRINT Program.
- The relationship between the guidance offered in this handbook and the methodologies currently used by the Army during the early portions of the MAP, (e.g., HARDMAN and ECA).
- How the results generated from the use of these predictive techniques can drive the later phases of the MAP in controlling OWL. What are the

means available to ensure this, (i.e., ROC , future test plans, DIDs, etc.).

We have revised the predictive handbook outline to reflect these changes. The revised predictive handbook outline dated 23May87 follows this subsection.

# REVISED WORKLOAD PREDICTION HANDBOOK

## OUTLINE

USER PROFILE: The Workload Prediction Handbook is intended for Army personnel (e.g., TRADOC combat developer and system manager) during the concept and early design phases of the materiel acquisition process (MAP). This user is interested in the different OWL measures and techniques applicable during early design. This user is typically the person who (1) makes the decision of which OWL assessment tools to use, and (2) adapts those tools to fit the specific needs and characteristics for the system of interest. To guide the user in performing these functions, the handbook will identify (based on system requirements and specific design objectives) the workload assessment methodology needed via a "matching model" procedure such that an optimal OWL Assessment Battery is offered. The handbook provides guidance on the identification and implementation of the OWL Assessment Battery for all types of systems.

FORMAT: This Handbook will be organized so to maximize its utility as a working document. Descriptions will be concise and to-the-point. For those users wanting additional background and supporting information, references and appendices will be provided. Decision trees, tables, and charts will be used whenever possible to assist the user in following the methodology contained in the Handbook.

GOAL: Provide the user a step-by-step approach to developing and implementing an OWL assessment program during early system development. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs (e.g., MANPRINT) , and methodologies (e.g., ECA and HARDMAN) that are used in the early phases of the materiel acquisition process (MAP).

LENGTH: approximately 75-100 pages

## I. INTRODUCTION

A. Definition of Operator Workload (OWL)

B. Traditional factors attributed to OWL, e.g., physical involvement of operators

C. New technologies and factors affecting system concepts, (e.g., automation via software)

D. New factors attributed to OWL, (e.g., mental/cognitive involvement of operators)

E. Impact of OWL on overall system performance

F. Army requirements, specifications, standards, and regulations for OWL

G. Relationship of OWL to MANPRINT Program

H. Purpose for handbook: methodology for determining and implementing an operator workload assessment program via OWL predictive techniques during concept and preliminary design phases

I. How to use this handbook; overview of contents.

STRATEGY: Introduce the user to key OWL concepts and requirements. Orient the user to the critical concept - OWL predictive assessment techniques are critical for identifying OWL issues such that solutions concerning OWL (overload) can be reached in a cost-effective way (proactive mode). Otherwise, potential OWL problems will probably be addressed in a reactive mode, (i.e., fixing past mistakes). Provide the framework on how to use the Handbook.

## II. OVERVIEW OF OPERATOR WORKLOAD PREDICTION

A. What is OWL prediction?

B. Relationship between methodology offered in this document and existing Army methodologies, (i.e., ECA, HARDMAN, Task Analysis)

C. The relationship between OWL prediction & OWL evaluation

D. Factors to consider for OWL prediction

1. System requirements
2. Operator capabilities/skills/behaviors required
3. OWL performance model - performance factors to consider
4. OWL assessment techniques

E. Methodology: Matching model for establishing an OWL Predictive Assessment Program

<u>STRATEGY</u>: Provide a global "mental map" for the user on the steps involved in workload prediction (analytic approach) and its relationship to OWL evaluation (empirical approach)

## III. OPERATOR WORKLOAD PREDICTION METHODOLOGY

A. Determine system performance requirements

1. Potential Sources:
   a. O & O Plans (Operational & Organizational)
   b. JMSNS (Justification of Major Systems New Starts)
   c. ECA (Early Comparability Analysis)

B. Determine operator actions/behaviors for system usage

1. Sources
   a. Requirement documents (O & O Plans, ROCs)
   b. Task analyses
   c. Expert opinions (SMEs)

d. Comparative systems (e.g., SMMP, ECA)

e. Mock-ups

f. Simulators

2. Classification of operator behaviors/actions required for system usage (cf., Universal Operator Behavior Dimensions - Berliner, Angell, & Shearer, 1964)

– Chart of Universal Operator Behaviors -

a. Searching for and receiving information

b. Identifying objects, actions, events

c. Problem solving

d. Decision making

D. Determine OWL performance model factors to incorporate into matching model methodology (decision making process)

E. Determine OWL assessment program

1. Decision rules for selecting an OWL predictive assessment battery
2. Decision tables for OWL methodologies that are applicable

F. Analytic assessment methods

1. Purpose: Prediction of OWL & "chokepoints"
2. Sensitivity
3. Representation of OWL issues/behaviors
4. Techniques
   a. Expert opinions
   b. Comparisons
   c. Simulations/Models
   d. Math models
   e. Task analytic methods
5. Interpretation of assessment results

<u>STRATEGY</u>: Provide the user a step-by-step approach to developing and implementing an OWL Predictive Assessment Program. Provide the user the know-how to integrate the OWL Assessment Program with existing requirements, programs, and methodologies that are part of the materiel acquisition process.

## IV. ITERATIVE NATURE OF OWL PREDICTION

A. Materiel acquisition process

B. System design decisions

C. How to address OWL issues in the MAP, (i.e., ROC, SMMP, and Test Plans)

STRATEGY: Establish the concept that the OWL assessment program (developed from using this Handbook) is an evolving program which will be modified as the materiel acquisition process progresses. OWL must be monitored and controlled by establishing requirements, (i.e., Measures of Effectiveness [MOEs] in the ROC), that ensure activities conducted after Milestone I address OWL issues that were identified from the use of the OWL predictive techniques.

## V. EXAMPLES

A. Examples will be provided for each of the assessment techniques.

STRATEGY: Provide the user with concrete examples of OWL predictive assessment programs. Provide reality to the OWL prediction methodology described in the Handbook.

## VI. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

## 4.4 EVALUATION HANDBOOK

### 4.4.1 Original Concept in Statement of Work (SOW)

The Workload Evaluation Handbook was originally conceived as a guide for addressing OWL during the conduct of concept evaluation, and developmental and operational testing (post-Milestone I activities). The handbook would direct Army personnel in employing OWL evaluation techniques (subjective, physiological, and objective/task measures) by identifying the most appropriate empirical technique with respect to their particular needs and resources. The techniques offered would lend themselves to be incorporated in any system evaluation effort and would complement any existing data/information on OWL collected earlier in the MAP (predictive techniques). These techniques provide data to substantiate design solutions/decisions to minimize OWL as well as direct future refinements for system design.

### 4.4.2 Rationale for Original Draft Outline and Revision

In general, our original draft outline attempted to provide a methodology for identifying the most appropriate evaluative technique for a given system during the various developmental phases phases after Milestone I activities. It also highlighted the importance of OWL, its relationship to system performance and previous OWL assessments conducted earlier during the MAP (OWL predictive techniques). The original handbook outline dated 9Feb87 is to be found in Appendix D.

Based on our meetings with Army personnel, we identified Army concerns that need to be addressed in the Evaluation Handbook. These concerns are the following:

- Emphasis on the coordination of previous OWL assessments (OWL predictive techniques) with subsequent testing and evaluation such that provisions are established (e.g., ROC, SMMP) to ensure that OWL concerns already identified are addressed adequately in the later phases of the MAP.
- Elaboration on the key roles that the various testing and evaluation agencies (OTEA, AMSAA, and TECOM) as well as system and training agencies (AMC and TRADOC) play in addressing OWL issues. All have a contribution to make in controlling OWL.
- Address the applicability of the methodology proposed in the handbook with respect to the Army's accelerated programs for system acquisition,

(i.e., ASAP and NDI), and the evolutionary development of systems, (i.e., PIP and P3I).

We have revised the evaluation handbook to reflect these concerns. The revised evaluation handbook outline dated 23May87 follows this subsection.

REVISED WORKLOAD EVALUATION HANDBOOK

OUTLINE

USER PROFILE: The Workload Evaluation Handbook is intended primarily for the Army community involved with developmental testing and evaluation (DT&E). These users are interested in interpreting the results of the various workload assessments conducted throughout the development cycle and are primarily concerned with system evaluation from many different perspectives (e.g., TRADOC, AMC , OTEA, AMSAA, and TECOM). These evaluators and users of data from test and evaluation (T&E) are also interested in how to perform OWL analysis. In addition, they are concerned with the actual constraints placed by real-world implementation of a workload assessment. Such constraints involve traditional (and non-traditional) limits on testbed resources (e.g., subjects, time, and funding). The T&E users are also concerned with how to transform OWL data and information into recommendations for system design.

FORMAT: This Handbook will be organized so to maximize its utility as a working document. Descriptions will be concise and to-the-point. For those users wanting additional background and supporting information, references and appendices will be provided. Decision trees, tables, and charts will be used whenever possible to assist the reader in following the methodology contained in the Handbook.

GOAL: Provide the user a step-by-step approach to developing and implementing an OWL assessment program. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs, and methodologies that are part of the military system acquisition cycle.

LENGTH: approximately 125-150 pages

## I. INTRODUCTION

A. Definition of Operator Workload (OWL)

B. Traditional factors attributed to OWL, (e.g., physical involvement of operators)

C. New technologies and factors affecting system concepts, (e.g., automation via software)

D. New factors attributed to OWL, (e.g., mental/cognitive involvement of operators)

E. Impact of OWL on overall system performance

F. Army requirements, specifications, standards, and regulations for OWL

G. Relationship of OWL to MANPRINT Program

H. Purpose for handbook: methodology for determining and implementing an operator workload assessment program via OWL evaluative techniques during concept evaluation and developmental and operational testing.

I. How to use this handbook; overview of contents.

STRATEGY: Introduce the user to the key OWL concepts and requirements. Orient the user to the critical concept - OWL Evaluative Techniques are crucial for determining the feasibility of design decisions as they relate to minimizing OWL. Provide the proper framework on how to use the handbook.

## II. OVERVIEW OF OPERATOR WORKLOAD EVALUATION

A. What is OWL evaluation?

B. Who is involved? (TRADOC, AMC, OTEA, AMSAA, TECOM, )

B. The relationship between OWL evaluation & OWL prediction

C. Factors to consider for OWL evaluation

1. System requirements
2. OWL assessment program constraints
   a. Subjects
   b. Time
   c. Funding
   d. Etc.
3. Operator capabilities/skills/behaviors required
4. Earlier OWL assessments (OWL prediction)
5. OWL performance model - performance factors to consider
6. OWL empirical assessment techniques

D. Methodology: Matching model for establishing an OWL Evaluative Assessment Program

STRATEGY: Provide a global "mental map" for the user on the steps involved in workload evaluation (empirical approach) and its relationship to OWL prediction (analytic approach), and system design.

## III. OWL ASSESSMENT (TEST AND EVALUATION)

A. Determine system performance requirements

1. Sources
   a. Requirement documents (ROC, and O & O Plans)

B. Determine operator actions/behaviors for system usage

1. Sources
   a. Task analyses
   b. Expert opinions
   c. Comparative systems
   d. Mock-ups

e. Simulators

2. Classification of operator behaviors/actions required for system usage (cf., Universal Operator Behavior Dimensions - Berliner, Angell, & Shearer, 1964) - Chart of Universal Operator Behaviors -

   a. Searching for and receiving information

   b. Identifying objects, actions, events

   c. Problem solving

   d. Decision making

C. Determine stage in materiel acquisition process

D. Determine OWL performance model factors to incorporate into matching model (decision making process)

   1. For example, environmental factors such as noise, vibration, heat, and cold

E. Determine OWL assessment program

   1. Decision rules for selecting an OWL Assessment battery

   2. Decision tables for workload methodologies that are applicable

F. Establish framework for the evaluation

   1. Task scenarios

G. Empirical Assessment Methods

   1. Purpose: Evaluate design decisions

   2. Sensitivity

   3. Task scenarios: representation

   4. Techniques

      a. Operator opinion

      b. Primary task

      c. Secondary task

      d. Physiological responses

   5. Interpretation of assessment results to impact system design

<u>STRATEGY</u>: Provide the user a step-by-step approach to implementing an OWL evaluative assessment program - test and evaluation. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs, and methodologies that are part of the materiel acquisition process.

## IV. ITERATIVE NATURE OF OWL EVALUATION

A. Materiel acquisition process (MAP) and Accelerated acquisition process (ASAP)

B. System design decisions

C. Army agencies involved in the iterative nature of OWL assessment - (TRADOC and AMC as key players )

STRATEGY: Establish the concept that OWL assessment (test and evaluation) is an iterative process that is conducted throughout the materiel acquisition process to ensure OWL is not a system problem.

## V. OWL CONCERNS AND ARMY SYSTEM DEVELOPMENT ITEMS

A. Non-Developmental Items (NDI)

B. Product Improvements (e.g., P3I, PIP)

STRATEGY: Elaborate on the special circumstances these areas present for addressing OWL and show the applicability of the methodology represented in this handbook to these set of circumstances.

## VI. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

# 5. SELECTION OF REPRESENTATIVE SYSTEMS

## 5.1 Introduction

The three representative system selected during the present effort are crucial to later efforts. They provide the test-bed upon which the validation of OWL measures and methodology will be later conducted (Task 4). In addition, these also provide the framework for illustration of applications which will augment of the documentation of our methods (OWL Handbooks) which will be subsequently be prepared (Task 5). Beyond thishowever, it is intended that the analyses of the prototype systems will provide significant benefits for their development and the Army. Delineated in the following are: the selection methodology (5.2), description of the selected systems (5.3), and brief discussion of on-going efforts (5.4).

## 5.2 Methodology

A two-stage approach was applied for selection of representative systems based upon Interview Inputs and Army Sponsor Guidance.

### 5.2.1 Interview Inputs

The first stage involved identification of candidate systems during our interviews of potential users and cognizant personnel within the Army (cf., Sect.3.2). Typically subsequent to description of the OWL Assessment Program, interviewees were presented with candidate system selection criteria. Most salient of these were requirements to: (1) select candidates requiring the broad range of predictive and evaluative OWL techniques and (2) select systems which could be realistically impacted within the time frame of the program efforts. The first of these, it is noteworthy, was reflected in interest with systems in different phases of the materiel acquisition process, and under different combat developers consequently representing a range of systems.The second requirement pointed toward systems undering rapid (NDI) or near-term changes in status. The interviews proved fruitful and pointed toward more than a dozen individual or families (e.g., AFV) of systems for joint consideration with ARI.

### 5.2.2 Army Sponsor Guidance

Candidates systems were weighed with respective to theobjectives and schedule of the present effort in a joint meeting 6-7 May at the ARI Field Unit, Ft. Bliss. Based upon information obtained in interview follow-ups, system candidates were first screened with respect to the program schedules of the various systems as well as assessability by the evaluation team. For surviving candidates, operators of interest were identified and evaluated. Group evaluations were made with respect to operator gross environmental exposure (impact); estimated relative levels of perceptual, cognitive, motor, and communication workload; as well as physiological workload levels imposed by manual tasks (lifting, pushing, carrying etc.). Representative systems were then selected so as to insure a range of perceptual, cognitive, motor, and communication workload levels across systems.

## 5.3 Selected Representative Systems

The selected representative systems include: (1) Line of Sight-Forward (Heavy) [LOS-F(H)]; (2) Automatic Target Handoff System [ATHS]; as well as (3) a Remotely Piloted Vehicle (RPV[AQUILA or IEW-UAV(I)]. In the following, each of these systems will initially be characterized with regard to nature, type of acquisition and status, as well as operators of interest. The comparison of the character of anticipated OWL will subsequently be overviewed across systems for the operators of interest.

### 5.3.1 LOS-F(H)

LOS-F(H) is one of five components of the Forward Area Air Defence (FAAD) System. FAAD as a whole is designed to defend force and critical assets against rotary wing and fixed wing aircraft threats during 24 hour day and night operations, a countermeasures environment, and adverse visibility and weather conditions. The LOS-F(H) component of FAAD will be a self propelled, armored, highly mobile, platform with a primary armament of launch-ready missiles as well as a complementary weapon providing full coverage of air defence within the dead zone of the missile. It is designed to provide front line air defence against attacks by high performance ground attack aircraft, attack helicopters, as well as self defence against armored vehicles and ground targets.

LOS-F(H) is being acquired under a NDI strategy aimed at fielding during 1991 which provides for evaluation of the breadth of measures of OWL. Candidate selection, Milestone I/II of the ASAP, is scheduled to be made on the basis of a competitive shoot-off to be conducted during September to December 1987. Follow-on testing of the selected candidate as will as Force Development Test and Evaluation (FDTE)is scheduled for Fiscal Year (FY) 88. LOS-F(H) has two operators of particular interest with respect to workload that may be nominally designated across system candidates as: (1) Gunner and (2) Squad Leader.

### 5.3.2 Automatic Target Handover System [ATHS]

The ATHS is designed to provide secure jam resistant digital communications and is envisioned as being a subsystem in a variety of future helicopter and other vehicles. With associated Navigation and Interrogation Friend or Foe (IFF) Subsystems, it is currently scheduled for integration into the APACHE AH-64A Aircraft (the draft RFP is under review). This integration is for facilitation of intelligent automatic digital data processing for missiles, weapons, and related information transfer between, other AH-64A, Scout Aircraft, and ground units via digital waveforms compatible with TACFIRE. For the AH-64A, the integration is to allow simultaneous operation by dual [Pilot and Copilot/Gunner (CPG)] control and display units which shall be night-vision goggle compatible. It is believed, however, that in flight the primary operator will be the CPG because of the flight control responsibilities of the Pilot. The CPG will have a message received indicator "that can be viewed/heard during all workload conditions". The CPG is the operator which has been identified for detailed workload evaluation.

### 5.3.3 Aquila/ IEW-UAV(I) Remotely Piloted Vehicles (RPVs)

The Aquila and Unmanned Air Vehicle - Intelligence Electronic Warfare (Interim) [IEW-UAV(I)] are RPV components of representative systems pointed to as having growing significance for the Army. Of these, the Aquila based system was judged somewhat more suitable for the goals of the present (OWL) effort because of its developmental maturity and history. However as it is under Full Scale Engineering Development (FSED), with an impending scheduled ASARC in June 1987, and it was deemed prudent to retain as a backup the IEW-UAV(I). Currently with broad opportunities

for the present (OWL) efforts because of its status as a NDI, the IEW-UAV(I) is being selected on the basis of an on-going flyoff and will be used for development of the specifications of final UAVs by Ft. Huechuca. Based upon initial analyses and the status of the IEW-UAV(I), it was judged that for the present purposes it could be considered analogous to (a larger) Aquila (with similar perceptual, cognitive, motor, and communication performance and workload problems). Consequently, Aquila will be delineated in the following both with regard to itself and as a surrogate for the IEW-UAV(I).

The Target Acquisition/Designation and Aerial Reconnaissance System (TADARS) Aquila RPV is an 'eye in the sky system' designed to provide the ground commander realtime battlefield information by detection, recognizing, identifying and designating enemy forces (ARI, 1987). The Acquila itself is a tailless mid-wing tactical mini-plane with a rear-mounted pusher propeller engine. Included as part of the system are a stabilized TV sensor and a laser rangefinder/designator on the aircraft, an antijam data link for communication with a ground control station, as well as personnel for operation. Basically fixed during operations, the ground control station may be noted as being located in an protected shelter in the rear of a MS14 5-Ton Truck. More interestingly, the data link may be noted as having has seven (0-6) levels of function which may impact on mission/modes(Search, Artillery and Track) performance and workload. Although more recent flight tests have implications regarding this of which we are not fully apprised (e.g., GAO, 1986; ARI, 1987, p.4), Hershberger et al., 1983 have previously reported suggestive results from "man in the loop" simulations. Aquila has three operators of which two have been identified for detailed workload evaluation:

(1) Vehicle Operator (VO) , and

(2) Mission Commander (MC).

### 5.3.4 OWL Overview For The Selected Systems

Figure 5.3.4-1 summarizes salient features of operator workload developed during the group evaluation meeting 6-7 May at Ft. Bliss (cf., 5.2.2). Examining this table, it may be seen that except for the Gunner in the LOS-F(H) (during loading operations), physiological workload is expected to relatively constant and minimal (Low). The group

judgements of perceptual, cognitive, motor, and communication workload levels may also be seen to span the range (Low-High).

## 5.4 Discussion

The three selected representative systems are the test-beds upon which the validation of OWL measures and methodology will be later conducted (Task 4). Although a large step, their selection is only the beginning of the development of an overall and system specific plans for the methodological validation be developed during the next phase of efforts (Task 3). To insure the success of the efforts, as well as provide for the significant benefit for the representative systems through OWL analysis, will require long and close collaboration with system and other cognizant personnel. In anticipation of this, personnel were identified during our interviews of users and other selected personnel within the Army (cf., Sect.3.2). Cognizant personnel are currently being contacted regarding the selection of systems and coordination of joint efforts in beginning.

| SYSTEM | OPERATOR | ENVIRON IMPACT | OWL CATEGORY LEVEL | | | | |
|---|---|---|---|---|---|---|---|
| | | | PERCEPTUAL | COGNITIVE | MOTOR | COMMUNICATION | PHYSIOLOGICAL |
| **LOS-F(H)** | GUNNER | MOD | MOD - HIGH | MOD | MOD - HIGH | LOW - MOD | LOW - MOD |
| | SQUAD LEADER | MOD | MOD - HIGH | MOD - HIGH | LOW | LOW - MOD | LOW |
| **ATHS** | COPILOT/ GUNNER | MOD - HIGH | LOW - MOD ? | MOD - HIGH | MOD - HIGH | LOW ? | LOW |
| **AQUILA / IEW-UAV(I)** | VEHICLE OPERATOR | LOW | MOD - HIGH ? | LOW - HIGH ? | HIGH | LOW - MOD | LOW |
| | MISSION COMMANDER | LOW | MOD - HIGH ? | MOD - HIGH ? | LOW | MOD - HIGH | LOW |

Figure 5.3.4-1 OWL Overview for the selected systems

## 6. OTHER PROGRAM PROGRESS

Noteworthy progress has been toward program goals which are tangential to the subject of the present report (re: Task 2). OWL information collection and analysis has been and is underway in preparation for the evaluation of workload measures which is to be conducted as part of the next phase of effort (i.e., Task 3). For the interested reader, details of the status, nature, and methods of this collection may be found delineated in the appendix describing the OWL Information System. The OWL information analysis effort, it is pertinent to observe, is based upon a taxonomy of workload assessment methods with two broad classes:

- Analytic - predictive techniques that may be applied earliest in system design before "man in the loop" studies; and

- Empirical - operator workload assessments that are taken during simulator, prototype, or system evaluations.

Analytic techniques have initially received our greatest interest and attention. This is partially because (although not in the context of the system evaluation objectives of the Army): (1) the empirical techniques have received considerable attention, (e.g., O'Donnell and Eggemeier, 1986); and (2) a model matching empirical techniques with user requirements has been been reported (Casper, et al.,1986) although apparently currently unavailable. Our motivation for focusing on the analytic techniques lies in their application during the earliest developmental stage where the greatest design flexibility is available at the least cost as pointed out earlier in this report (cf., Sect. 2). Thus far, we have classified these analytic techniques into five categories:

- Comparability Analysis -- This category involves the application of existing workload data from an comparable earlier system to estimate the workload for the system under development (e.g., Shaffer, et al., 1986).

- Mathematical Models -- Various mathematical techniques have been used in a theoretical context for a long time. Transfer functions, information theory, and queuing theory are some of the techniques of this category (e.g., Senders, 1964). These provide basic limits or boundaries which may be applied during "front end analysis" with regard to OWL.

- Expert Opinion -- The category relies on the opinion of experts who have intimate working knowledge of the mission objectives, the operational environment and the workload of comparable systems . This category, in contrast to listed below, relies upon experts to identify

choke-points and does not require formal task analyses (Zachary, 1981).

- Task Analytic Techniques -- This category involves the development of a mission profile which represents the way the system is to be used. A number of investigators have used the approach (e.g., Stone, Gulick, and Gabriel, 1985). The profile makes it possible to perform a task analysis for a given work station and translate it into activity profiles as a function of time. This procedure will uncover major situations in which the time available to perform the task (mission) exceeds the time available.

- Simulation Models -- These attempt to model human behavior and thereby predict performance. Some operate at the level of operator tasks (task analysis) to predict level of performance (e.g. Siegel and Wolf, 1969). Others extend the task analysis approach and carry the scenario into far more detail; macro and micro models of components of the task are used to build accuracy and time-line projections of human performance (e.g., Harris, et al., 1986).

We are presently documenting a procedure for the selection from among these analytic categories based on user requirements and resources. As an initial step, this procedure distinguishes OWL comparability analyses from other categories by the requirement for comparable system data. In subsequent steps going from Mathematical Models to Simulation Models, the other categories are distinguished by their increasing requirements for formal system and operator task definitions. Our plan is to shortly complete an overview of our procedure for selection among analytic assessment of OWL (Hill, et al., in preparation).

# 7. FUTURE PLANS

## 7.1 Future Plans for Subsequent Tasks

Task 3 will consist of a critical review and evaluation of OWL measurement techniques (predictive and evaluative) and the development of validation plans for the OWL methodology to be applied to the three Army prototype systems.

Validation plans will be prepared to include OWL measures that offered the greatest utility and impact on the prototype systems described earlier [LOS-F(H), ATHS, and Aquila/IBW-UAV(I)]. For each system , a goal of the validation plans will be to utilize families of OWL techniques. For example, a family of predictive techniques (e.g., expert opinion, simulation models) will be applied to systems in order to assess their relative utility in providing similar types of information before man-in-the-loop simulations. Similarly, a family of evaluative techniques (e.g., subjective techniques such as SWAT, TLX, and Modified Cooper-Harper Scales) will be applied to systems in order to assess their relative utility in providing information during man-in-the-loop evaluations. The validation plans will be structured to be reflective of crew workload issues to the extent possible within the validation effects. OWL analyses will also be directed at ensuring benefit for the selected systems.

In Task 4, the plans generated in Task 3 will be implemented. We will conduct studies to validate the OWL measures and methodology while performing OWL analyses on the three selected systems. In addition to demonstrating and validating the OWL methodology, it is intended that the analyses of the prototype systems will provide significant and direct benefits for the development of these systems. This is extremely important since the success of this OWL program will be direct function of the Army community's reaction to our approach. The more we can document our "successes" in using this methodology, the greater the likelihood that the Army community will be receptive to using our methodology (products).

Task 5 will address the production of the primary documentation of the OWL program. We will produce three products: Manager's OWL Pamphlet, OWL Prediction Handbook and an OWL Evaluation Handbook. A Post-Contract Survey form will be prepared to provide an efficient vehicle to assess the degree to which these OWL

documents have met their goals for the Army. The technical report detailing the scientific basis for the information contained in the pamphlet and handbooks, and discussing further research in the area of controlling operator workload will be prepared as the final product for the Army.

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## DOD PUBLICATIONS

| | | | |
|---|---|---|---|
| DoD Directive | 5000.1 | Major Systems Acquisitions. | 12 Mar 86. |
| DoD Instruction | 5000.2 | Major System Acquisition Procedures | 12 Mar 86. |
| DoD Directive | 5000.3 | Test and Evaluation | 12 Mar 86. |

## ARMY REGULATIONS:

| | | |
|---|---|---|
| AR 40-10 | Health Hazard Assessment Program in Support of Army Materiel Acquisition Decision Process | 15 Oct 83. |
| AR 70-1 | System Acquisition Polocy and Procedures. | 1 Dec 86. |
| AR 70-8 | Personnel Performance and Training Program | |
| AR 70-10 | Test and Evaluation | 30 Apr 86. |
| AR 70-15 | Product Improvement of Material | 15 Jun 80. |
| AR 71-3 | User Testing | 1 Mar 86. |
| AR 71-9 | Materiel Objectives and Requirements | 20 Mar 87. |
| AR 385-16 | System Safety Engineering and Management | 3 Sep 85. |
| AR 602-1 | Human Factors Engineering Program | 15 Feb 83. |
| AR 602-2 | Manpower and Personnel Integration (MANPRINT) in Materiel Acquisition Process | 18 May 87. |
| AR 611-201 | Enlisted Career Management Fields and Military Occupational Specialitites | |
| AR 700-127 | Integrated Logistics Support | 16 Dec 86. |
| MIL-H-46855B | Military Specification: Human Engineering Requirements for Military Systems, Equipment and Facilities | 31 Jan 79. |
| MIL-STD 1472C | Military Standard: Human Engineering Design Criteria for Military Systems, Equipment and Facilities | 2 May 81. |
| AMC Reg. 70-52 | System Engineering | 30 Sep 86. |
| DA Pam. 11-25 | Life Cycle System Management Model for Army Systems | 1 May 75. |

| | | |
|---|---|---|
| DARCOM/TRADOC Pam 70-2 | Materiel Acquisition Handbook | 20 Jan 84. |
| TECOM Pam. 602-1 | Man-Materiel Systems: Questionnaires and Interview Design (Subjective Testing Techniques) | 25 Jul 75. |
| TECOM TOP 1-2-610 | Human Factors Engineering Data Guide for Evaluation | 30 Nov 83 |
| ADS-30 | Aeronautical Design Standard: Human Engineering Requirements for Measurement of Operator Workload. St. Louis, MO: USAVSC. | |

Appendix A

OPERATOR WORKLOAD (OWL) SURVEY

ARI CONTRACT NO. MDA903-86-C-0384

PLEASE RETURN TO:
ANALYTICS INC. ( ATTN: OWL)
2500 MARYLAND ROAD
WILLOW GROVE, PA. 19090
(215) 657-4100 x.164

## RESPONSIBILITIES/ROLES IN THE MATERIEL ACQUISITION PROCESS (MAP)

1. PLEASE INDICATE YOUR ROLE(S) IN THE MAP.
   (CHECK APPROPRIATE ITEM(S). )

   ____ DEFINE OR REVIEW REQUIREMENTS, STANDARDS, CRITERIA

   ____ DEVELOP OR MONITOR THE DESIGN OF EMERGING SYSTEM CONCEPTS

   ____ DESIGN OR MONITOR THE CHARACTERISTICS OF EARLY PROTOTYPE SYSTEMS

   ____ TEST AND EVALUATION OF SYSTEMS (EARLY, MID-TERM, LATE) DURING MAP.

   ____ OTHER (PLEASE SPECIFY:________________________________________
   ________________________________________________________________)

2. FOR OR TO WHOM DO YOU RESPOND - WHOSE TASKS/DIRECTIVES DO YOU USE TO DO YOUR WORK? (CHECK APPROPRIATE ITEMS)

   ____ OPM (OFFICE PROGRAM MANAGER)

   ____ TSM (TRADOC SYSTEM MANAGER)

   ____ DCD (DIRECTORATE OF COMBAT DEVELOPMENT)

   ____ DOTD (DIRECTORATE OF TRAINING DEVELOPMENT)

   ____ T&E DIV/BD (TEST & EVALUATION)

   ____ OTHER (PLEASE SPECIFY: ________________________________________
   ________________________________________________________________)

3. WHAT GUIDANCE AND ASSISTANCE DO YOU USE IN FULFILLING YOUR RESPONSIBILITY? (CHECK APPROPRIATE SOURCES AND SPECIFY)

A. DOCUMENTS:

___ DOD #____________________

___ AR #____________________

___ FM #____________________

___ TM #____________________

___ OTHER DOCUMENTATION (PLEASE SPECIFY: ____________________
____________________________________________________________)

B. AGENCIES: PLEASE SPECIFY (e.g., HEL, ARI...)

____________________________________________________________

____________________________________________________________

____________________________________________________________

4. TYPICALLY, WHO USES THE OUTPUT OF YOUR EFFORTS AND PRODUCTS ? (PLEASE SPECIFY)

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

5. HOW OFTEN DO YOU CONSIDER THE FOLLOWING PERFORMANCE AREAS IN FULFILLING YOUR JOB RESPONSIBILITIES?

| (CHECK IN APPROPRIATE BOXES) | OFTEN | SOMETIMES | RARELY | NEVER |
|---|---|---|---|---|
| TOTAL SYSTEM PERFORMANCE | | | | |
| SUBSYSTEM PERFORMANCE | | | | |
| OPERATOR PERFORMANCE | | | | |
| MAINTAINER PERFORMANCE | | | | |

6. HOW OFTEN DO YOU CONSIDER THE FOLLOWING HUMAN PERFORMANCE AREAS IN FULFILLING YOUR JOB RESPONSIBILITY?

| (CHECK IN APPROPRIATE BOXES) | OFTEN | SOMETIMES | RARELY | NEVER |
|---|---|---|---|---|
| HUMAN FACTORS ENGINEEERING | | | | |
| MANPOWER | | | | |
| PERSONNEL | | | | |
| TRAINING : | | | | |
| INDIVIDUAL SOLDIERS | | | | |
| UNIT | | | | |
| SAFETY | | | | |
| HEALTH HAZARDS | | | | |
| OTHER: PLEASE SPECIFY ________________ | | | | |

## OPERATOR/ MAINTAINER WORKLOAD

7. DOES THE ISSUE OF OPERATOR AND MAINTAINER WORKLOAD (OWL) LEVEL GET CONSIDERED IN YOUR WORK ?

| OFTEN | SOMETIMES | RARELY | NEVER |
|---|---|---|---|
| | | | |

IF EVER, HOW DO YOU ADDRESS OWL? (e.g., SPECIFIC TOOLS, EDUCATED GUESSES)

8. WHAT SPECIFIC GUIDANCE OR DOCUMENTS DO YOU NOW USE TO ADDRESS OWL? e.g., ARS, LOCAL REGs, SOPs.

9. HOW OFTEN SHOULD THE ISSUE OF WORKLOAD LEVELS BE CONSIDERED IN YOUR JOB?

| OFTEN | SOMETIMES | RARELY | NEVER |
|---|---|---|---|
| | | | |

10. HOW WOULD YOU LIKE TO ADDRESS OWL ?

________________________________________

________________________________________

________________________________________

________________________________________

11. WHAT GUIDANCE WOULD YOU LIKE TO HAVE FOR ADDRESSING OWL? (e.g. POC, DOCUMENT...)

________________________________________

________________________________________

________________________________________

________________________________________

12. DO YOU FORESEE AN INCREASED CONCERN WITH OWL DUE TO:
(CHECK APPROPRIATE ITEM(S))

_____ CHANGES IN TECHNOLOGY

_____ CHANGES IN REQUIREMENTS

_____ OTHER (PLEASE SPECIFY:____________________________)

_____ NONE

## BACKGROUND INFORMATION

YOUR TITLE :______________ GRADE / RANK ______________

POSITION:______________________________________________

YRS. IN CURRENT POSITION: ____________________________

AGENCY / UNIT: ______________________________________

SYSTEMS INVOLVED WITH (NEAR PAST, CURRENT, NEAR FUTURE)

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

WE WOULD LIKE TO CONTACT PERSONS FURTHER ABOUT OWL ISSUES. IF YOU ARE WILLING TO BE CONTACTED VIA PHONE, PLEASE FILL-IN THE INFORMATION REQUESTED BELOW.

NAME:____________________________ PHONE # :____________

Appendix B

DATE: 9FEB87

PROGRAM MANAGER'S OPERATOR WORKLOAD ASSESSMENT PAMPHLET

OUTLINE

USER PROFILE: The intended user for the pamphlet is the program manager who is involved in both delineating the needs, and developing the requirements for a new system. This user is not interested in the details of workload estimation or evaluation. This user also is not interested in which measures or which techniques offer the best OWL assessment. However, what IS of interest to the TRADOC or AMC system manager is high-level guidance on what are the Army requirements regarding workload, and what high-level provisions should be built into the system acquisition strategy for the assessment of OWL.

FORMAT: This Pamphlet will be structured to provide a concise, easily understood presentation of the role of OWL control in the materiel acquisition process (MAP). Tables, charts, flow diagrams, and specific examples will be used liberally to promote quick apprehension of concepts.

GOAL: Provide the reader with an overview of the role of OWL control in the materiel acquisition process, including the nature of the problem, DoD documents and requirements concerning OWL control, and available technologies to assist the Army program manager in effecting OWL control. Provide guidance in accessing other OWL control resources, especially the OWL Prediction and Evaluation Handbooks.

LENGTH: approximately 40-50 pages

## I. INTRODUCTION

A. Definition of Operator Workload (OWL)

B. Requirements, specifications, standards, and regulations for OWL

C. Impact of OWL on Army Mission Functions

D. Relationship of OWL to MANPRINT

E. TRADOC Contributions in responding to OWL concerns

F. AMC Contributions in responding to OWL concerns

G. Description of the contents of this pamphlet, how to use this pamphlet

STRATEGY: Introduce the user to the key OWL concepts and regulations. Provide the proper framework on how to use this handbook.

## II. OVERVIEW OF OWL FUNDAMENTALS

A. OWL Performance Model

B. OWL with various types of actions/behaviors

1. Searching for and receiving information
2. Identifying objects, actions, events
3. Problem solving
4. Decision making

C. OWL considerations for system types

1. Aviation

2. C3I

3. Air defense

4. Armored/Mechanized operations

5. Maintenance

6. Supply

D. OWL considerations during the Materiel Acquisition Process (MAP)

E. OWL Assessment Program

1. Prediction (analytic approach)

2. Evaluation (empirical approach)

3. Analysis of results

F. OWL Control Plan

STRATEGY: Provide a global "mental map" for the user on the key areas and steps involved in OWL prediction/evaluation and its relationship to the materiel acquisition process.

## III. OWL IN REQUIREMENTS ANALYSIS/CONCEPT FORMULATION

A. TRADOC perspective

B. AMC perspective

C. OWL trade offs in concept formulation

D. Development of a preliminary OWL Control Plan

E. Key OWL resources

1. Documents

2. Organizations (e.g, HEL, ARI)

3. Individuals (i.e., HFE specialists)

F The TRADOC System Manager's (TSM) OWL Concept Formulation Check List

1. What should the TSM be ensuring is accomplished.

G. The AMC Program Manager's (PM) OWL Concept Formulation Check List

1. What should the PM be ensuring is accomplished.

STRATEGY: Provide the user a step-by-step approach to developing and managing an OWL Control Plan during requirements analysis and concept formulation. Provide the user the know-how to integrate the OWL Control Plan with existing requirements, programs, and other control plans that are part of the materiel acquisition process.

## IV. OWL IN SYSTEM DEVELOPMENT

A. The OWL Control Plan

B. Methods for assessment

1. OWL Prediction (analytic approach)
2. OWL Evaluation (empirical approach)

C. Key OWL resources

1. Documents
2. Organizations (e.g., HEL, ARI)
3. Individuals (i.e., HFE specialists)

D. TSM OWL Check List for OWL Prediction

E. TSM OWL Check List for OWL Evaluation

F. AMC PM OWL Check List for OWL Prediction

G. AMC PM OWL Check List for OWL Evaluation

STRATEGY: Provide the user a step-by-step approach to developing and managing an OWL Control Plan during system development. Provide the user the know-how to integrate the OWL Assessment Program with existing requirements, programs, and other control plans that are part of the materiel acquisition process.

## V. ITERATIVE NATURE OF OWL ASSESSMENT

A. Materiel acquisition process

B. System design decisions

C. Evolution of OWL considerations

STRATEGY: Establish the concept that the OWL Assessment Program and its management and control are evolving processes which are modified as the materiel acquisition process progresses.

## VI. EXAMPLE

A. An example will be provided that delineates both TSM and AMC PM development and implementation of their respective OWL Control Plans.

STRATEGY: Provide the user with a concrete example of an OWL Control Plan.

## VII. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

## Appendix C

DATE: 9FEB87

# WORKLOAD PREDICTION HANDBOOK

## OUTLINE

USER PROFILE: The Workload Prediction Handbook is intended for the system designer during the concept and early design phases of the military system acquisition cycle. This user is interested in the different OWL measures and techniques applicable during early design. This user is typically the person who (1) makes the decision of which OWL assessment tools to use, and (2) adapts those tools to fit the specific needs and characteristics for the system of interest. To perform these functions, the system designer will identify the system requirements and specific design objectives for which the workload assessment methodology is needed and will use "the matching model" procedure to select an optimal OWL Assessment Battery. The handbook provides guidance on the implementation of the OWL Assessment Battery.

FORMAT: This Handbook will be organized so to maximize its utility as a working document. Descriptions will be concise and to-the-point. For those users wanting additional background and supporting information, references and appendices will be provided. Decision trees, tables, and charts will be used whenever possible to assist the user in following the methodology contained in the Handbook.

GOAL: Provide the user a step-by-step approach to developing and implementing an OWL assessment program during early system development. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs, and methodologies that are part of the materiel acquisition process (MAP).

LENGTH: approximately 75-100 pages

## I. INTRODUCTION

A. What is Operator Workload (OWL)?

B. Requirements, specifications, standards, and regulations for OWL

C. System performance and operator workload (system requirements)

D. Operator workload performance model: variables/factors to consider

E. Purpose for handbook: methodology for determining and implementing an operator workload assessment program during concept and preliminary design phases

F. How to use this handbook; overview of contents.

STRATEGY: Introduce the user to key OWL concepts and requirements. Orient the user to the critical concept - the OWL Performance Model - that underlies the methodology for workload prediction. Provide the framework on how to use the Handbook.

## II. OVERVIEW OF OPERATOR WORKLOAD PREDICTION

A. What is OWL prediction?

B. The relationship between OWL prediction & OWL evaluation

C. Factors to consider for OWL prediction

1.System requirements, (i.e., system performance)

2.Operator capabilities/skills/behaviors required

3.Stage in materiel acquisition process

4.OWL performance model

5.OWL assessment techniques

D. Matching model for establishing an OWL Assessment Program

STRATEGY: Provide a global "mental map" for the user on the steps involved in workload prediction (analytic approach) and its relationship to OWL evaluation (empirical approach)

## III. OPERATOR WORKLOAD PREDICTION METHODOLOGY

A. Determine system performance requirements

1. Justification

   a. JMSNS (Justification of Major Systems New Starts)

   b. MIL-H-46855B

2. Requirement source documents (cf., DoD Directive 5000.2, AR 15-14, AR 70-1, AR 70-10, AR 71-3)

B. Determine operator actions/behaviors for system usage

1. Sources

   a. Requirement documents

   b. Task analyses

   c. Expert opinions

   d. Comparative systems

   e. Mock-ups

   f. Simulators

2. Classification of operator behaviors/actions required for system usage(cf., Universal Operator Behavior Dimensions - Berliner, Angell, & Shearer, 1964)

   – Chart of Universal Operator Behaviors -

   a. Searching for and receiving information

   b. Identifying objects, actions, events

c. Problem solving

d. Decision making

C. Determine stage in materiel acquisition process

1. Mission area analysis and JMSNS

2. Concept and exploration phase

D. Determine OWL performance model factors to incorporate into matching model (decision making process)

E. Determine OWL assessment program

1. Decision rules for selecting an OWL battery

2. Decision tables for workload methodologies

F. Analytic assessment methods

1. Purpose: Prediction of OWL & "chokepoints"

2. Sensitivity

3. Representation of OWL issues/behaviors

4. Techniques

a. Expert opinions

b. Comparisons

c. Simulations/Models

d. Math models

e. Task analytic methods

5. Interpretation of assessment results

STRATEGY: Provide the user a step-by-step approach to developing and implementing an OWL Assessment Program. Provide the user the know-how to integrate the OWL Assessment Program with existing requirements, programs, and methodologies that are part of the materiel acquisition process.

## IV. ITERATIVE NATURE OF OWL PREDICTION

A. Materiel acquisition process

B. System design decisions

C. etc..

STRATEGY: Establish the concept that the OWL assessment program (developed from using this Handbook) is an evolving program which will be modified as the materiel acquisition process progresses.

## V. EXAMPLES

A. Examples will be provided for each of the assessment techniques.

STRATEGY: Provide the user with concrete examples of OWL assessment programs. Provide reality to the OWL prediction methodology described in the Handbook.

## VI. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

Appendix D

DATE: 9FEB87

# WORKLOAD EVALUATION HANDBOOK

## OUTLINE

USER PROFILE: The Workload Evaluation Handbook is intended primarily for the TRADOC community as well as system designer involved with early developmental testing (DT&E). These users (e.g., TRADOC) are interested in interpreting the results of the various workload assessments conducted throughout the development cycle but are primarily concerned with system evaluation. These evaluators are responsible for test and evaluation (T&E) but are also (like the designer) interested in how to perform OWL analysis. In addition, they are more concerned than the designer in the actual constraints placed by real-world implementation of a workload assessment. Such constraints involve traditional (and non-traditional) limits on testbed resources (e.g., subjects, time, and funding). The T&E users are also concerned with how to transform OWL data and information into recommendations for system design.

FORMAT: This Handbook will be organized so to maximize its utility as a working document. Descriptions will be concise and to-the-point. For those users wanting additional background and supporting information, references and appendices will be provided. Decision trees, tables, and charts will be used whenever possible to assist the reader in following the methodology contained in the Handbook.

GOAL: Provide the user a step-by-step approach to developing and implementing an OWL assessment program. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs, and methodologies that are part of the military system acquisition cycle.

LENGTH: approximately 125-150 pages

CONTENTS

## I. INTRODUCTION



STRATEGY: Introduce the user to the key OWL concepts and requirements. Orient the user to the critical concept - OWL Performance Model - that underlies OWL evaluation. Provide the proper framework on how to use the handbook.

## II. OVERVIEW OF OPERATOR WORKLOAD EVALUATION

A. What is OWL evaluation?

B. The relationship between OWL evaluation & OWL prediction

C. Factors to consider for OWL evaluation

1. System requirements , i.e., system performance
2. OWL assessment program constraints
    a. Subjects

    b. Time

    c. Funding

    d. Etc.
3. Operator capabilities/skills/behaviors required
4. Materiel acquisition process
5. Earlier OWL assessments (OWL prediction)
6. OWL performance model
7. OWL assessment techniques

D. Matching model for establishing an OWL Assessment Program

STRATEGY: Provide a global "mental map" for the user on the steps involved in workload evaluation (empirical approach) and its relationship to OWL prediction (analytic approach), materiel acquisition process, and system design.

## III. OWL ASSESSMENT (TEST AND EVALUATION)

A. Determine system performance requirements

1. Requirement source documents(cf., DoD Directive 5000.2, AR 15-14, AR 70-1, AR 70-10, AR 71-3

B. Determine operator actions/behaviors for system usage

1. Sources

   a. Requirement documents

   b. Task analyses

   c. Expert opinions

   d. Comparative systems

   e. Mock-ups

   f. Simulators

2. Classification of operator behaviors/actions required for system usage (cf., Universal Operator Behavior Dimensions - Berliner, Angell, & Shearer, 1964) - Chart of Universal Operator Behaviors -

   a. Searching for and receiving information

   b. Identifying objects, actions, events

   c. Problem solving

   d. Decision making

C. Determine stage in materiel acquisition process

D. Determine OWL performance model factors to incorporate into matching model (decision making process)

1. For example, environmental factors such as noise, vibration, heat, and cold

2. Sustaining period

E. Determine OWL assessment program

1. Decision rules for selecting an OWL battery

2. Decision tables for workload methodologies

F. Establish framework for the evaluation

1. Task scenarios

G. Empirical Assessment Methods

1. Purpose: Evaluate design decisions

2. Sensitivity

3. Task scenarios: representation

4. Techniques

   a. Operator opinion

   b. Primary task

   c. Secondary task

   d. Physiological responses

5. Interpretation of assessment results

STRATEGY: Provide the user a step-by-step approach to implementing an OWL assessment program - test and evaluation. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs, and methodologies that are part of the materiel acquisition process.

## IV. ITERATIVE NATURE OF OWL EVALUATION

A. Materiel acquisition process

B. System design decisions

STRATEGY: Establish the concept that OWL assessment (test and evaluation) is an iterative process that is conducted throughout the materiel acquisition process to ensure OWL is not a system problem.

## V. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

## APPENDIX E

## OWL INFORMATION SYSTEM

An OWL Information System is under development to provide for the control and analysis of the mass of documents and other resources comprising the OWL scientific database. Currently under implementation, the system is comprised of several components. One of these is a computerized database, to collect, to organize, to analyze, and to retrieve relevant citations and information associated with those citations. For convenience, we will discuss this aspect in terms of the OWL Information Data Base and the OWL Analysis System. The second part consists of a library consisting of the physical documents keyed to the database for easy retrieval.

Overall, this effort constitutes part of our effort for the development a set of useful tools for the analysis of operator workload, providing decision aids, and an information support system for practitioners.

## OWL INFORMATION DATA BASE

The data base contains standard bibliographic information on each report or article. The software chosen is dBASE III which provides a convenient and widely used relational database and program system for IBM-PC's and compatible machines. The hardware environment was selected to be broadly compatible with government standard microcomputer systems. The overall system is composed of several data files and a number of accompanying dBASE III programs to access and manipulate the data files. Development of the system to this point has been done carefully to provide flexibility in retrieving citations based on particular user needs. Some additional programs will be useful, but these are being done as the need arises.

The OWL reference database now numbers about 1400 reference items and is growing steadily. There are several additional bibliographies which have not yet been entered, for example, one created by Douglas Aircraft Company which consists of approximately 700 items and is supposed to be available soon in dBASE III format. As we

review the actual documents in the database, additional references of interest are being collected from the reviewed documents as well as from direct contact with authors of documents already entered.

The database system was designed to access the information in a number of different ways to accommodate various users, those working on the project and more importantly, those who will be in need of the information when the project is completed. Each bibliographic record is composed of a number of fields as shown in Table E-1. A form has been prepared to facilitate preparation of material for entry into the database (Figure E-1). Of note, are the keyterm (in title) fields which facilitate access by title.

A large number of reports are possible to generate citation listings. The report programs which have been developed to facilitate access of the database are:

- Complete report, alphabetized by authors. This lists all citations.
- Report for all citations for a single author
- Report selecting by keywords, such as "physiological measures" whereby a report is generated that lists all citations under this topic.
- Report listing of references with copies in house
- Several utility reports for editing, etc.

These report programs currently provide bibliographies in two standard forms: Human Factors Society and American Psychological Association. The programs are developed so that others could be added easily. Additionally, several programs have been developed to enter and edit the reference file along with necessary utility programs. The development of these programs allows the user to enter additional references and reviews and still maintain the system easily.

## OWL INFORMATION ANALYSIS SYSTEM

While the bibliographic file will be of general use, the more important part of the data base consists of a separate file containing the reviews produced by members of the Analytics, Inc. OWL team. The reviews are based on objective and standard classification techniques. The review form is shown in Figure E-2 and the structure of the review data

file is shown in Table E-2. This analysis follows the taxonomy presented by Wierwille and Williges (1978) which was in turn, modeled on the taxonomy developed earlier by Berliner, Angell, and Shearer (1964). We have augmented this analysis with the addition of statistical and observer/subject categories, some of which were suggested from an analysis done by Douglas Aircraft Company. Ultimately, most papers will be reviewed.

The reviews are entered into a second, separate data file, linked to the reference file by item number (and first author as a check). (Item No. is an arbitrary number assigned principally on order of entry.) The use of separate files permits multiple reviews (several reviewers) on a given paper and takes advantage of the relational database properties of dBASE III. To date, reviews for approximately 100 papers have been entered; this aspect will receive considerable attention in the near future as we enter into Task 3.

As the number of reviews entered into the system increases, we will develop a report generator to permit the user easy access using the information contained in the reviews.

## OWL LIBRARY

The OWL Library is being assembled through both formal and informal sources. The sources include publications available through DTIC and NTIS, journal articles, conference proceedings, conference papers, monographs, dissertations, etc.

Additionally, documents are being sought directly from well established workload laboratories, e.g., NASA Ames and NASA Langley, Air Force AMHRL, etc. Also, letters are being sent directly to authors already in the database to solicit copies of their work as well as any work which is new or was inadvertently missed on the first pass through other sources. Currently we are receiving 20 to 30 documents a week from authors with approximately 20% being additions to the reference database.

TABLE E-1

Listing and description of fields in OWL reference database

| Description | FIELD NAME | TYPE | LENGTH | DECIMAL |
|---|---|---|---|---|
| Owl database # | ITEMNO | N | 8 | 3 |
| Review done | REVIEWED | C | 1 | |
| Lib. Catelog # | CATALOG | C | 12 | |
| Report No. | REPORTNO | C | 25 | |
| Title - Article | ARTICLE | C | 250 | |
| Title - Book | BOOKTITLE | C | 250 | |
| First Author | AUTHOR1 | C | 25 | |
| Second Author | AUTHOR2 | C | 25 | |
| Third Author | AUTHOR3 | C | 25 | |
| Fourth Author | AUTHOR4 | C | 25 | |
| Fifth Author | AUTHOR5 | C | 25 | |
| Corp. Author | CORPAUTHOR | C | 100 | |
| Vol. Editor | EDITOR | C | 60 | |
| Book Co. | PUBLISHER | C | 80 | |
| Journal | JOURNAL | C | 80 | |
| Year of Pub. | PUBYEAR | C | 4 | |
| Volume | VOLUME | C | 8 | |
| Pages | PAGES | C | 13 | |
| Keyterm | KEYTERM1 | C | 50 | |
| Keyterm | KEYTERM2 | C | 50 | |
| Keyterm | KEYTERM3 | C | 50 | |
| Keyterm | KEYTERM4 | C | 50 | |
| Keyterm | KEYTERM5 | C | 50 | |
| Do we have? | INHOUSE | C | 1 | |
| Notes | NOTES | C | 250 | |
| Date entered | DATE | C | 8 | |

FIGURE E-1

OWL REFERENCE ENTRY FORM

Item No. ________(Assigned by computer)

---

Author 1 : ______________________ Author 2 : ______________________

Author 3 : ______________________ Author 4 : ______________________

Author 5 : ______________________

CORP. AUTHOR: ______________________________________________

(Use if no authors)______________________________________________

TITLE:(Journal, Article, Book, or Chapter)

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

EDITOR(s):__________________________________________________

BOOKTITLE(For editted books,proceed.):

____________________________________________________________

____________________________________________________________

____________________________________________________________

REPORT NO.______________________

JOURNAL:________________________________________________________

PUBLISHER:(Use only if Booktitle used; Place & pub. company)

________________________________________________________________

Year of Publication: _____ Volume (& No.): _____(___) Pages: ___________

Keyterm 1 :____________________________________________

Keyterm 2 :____________________________________________

Keyterm 3 :____________________________________________

Keyterm 4 :____________________________________________

Keyterm 5 :____________________________________________

Copy of Paper in house? __ (Y or N)

Notes:(250 characters)

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

Table E-2.

| Description | FIELD NAME | TYPE | LEN | DECIMAL |
|---|---|---|---|---|
| **GENERAL** | | | | |
| OWL Database # | ITEMNO | N | 8 | 3 |
| First Author | AUTHOR1 | C | 25 | |
| Reviewer | REVIEWER | C | 20 | |
| Review rating | RATING | C | 2 | |
| **REPORT NATURE or TYPE (TYPE)** | | | | |
| DoD | TYPE1 | C | 1 | |
| Theoretical | TYPE2 | C | 1 | |
| Review | TYPE3 | C | 1 | |
| Bibliographic | TYPE4 | C | 1 | |
| Methodological | TYPE5 | C | 1 | |
| Lab Experimentation | TYPE6 | C | 1 | |
| System application | TYPE7 | C | 1 | |
| Specific system | TYPE7S | C | 25 | |
| **FIDELITY (FIDEL)** | | | | |
| Actual system | FIDEL1 | C | 4 | |
| Simulation | FIDEL2 | | | |
| Applied Lab | FIDEL3 | | | |

| | | | |
|---|---|---|---|
| Basic Lab | FIDEL4 | | |

## ANALYTIC TAXONOMY (TAXA)

| | | | |
|---|---|---|---|
| Expert Opinion | TAXA1 | C | 1 |
| Comparison | TAXA2 | C | 1 |
| Simulation Models | TAXA3 | C | 1 |
| Math Models | TAXA4 | C | 1 |
| Manual | TAXA41 | C | 3 |
| Info Theor. | TAXA42 | | |
| Other | TAXA43 | | |
| Task Analytic | TAXA5 | C | 1 |

## EMPIRICAL TAXANOMY (TAXE)

| | | | |
|---|---|---|---|
| Primary task | TAXE1 | C | 1 |
| Performance rel | TAXE11 | C | 3 |
| Strategy rel. | TAXE12 | | |
| Other | TAXE13 | | |
| Secondary task | TAXE2 | C | 1 |
| Subsid. task | TAXE21 | C | 4 |
| Probe task | TAXE22 | | |
| Dual taks | TAXE23 | | |
| Other | TAXE24 | | |

| | | | |
|---|---|---|---|
| Subjective scales | TAXE3 | C | 1 |
| Rating Scales | TAXE31 | C | 5 |
| CH | TAXE311 | C | 5 |
| MCH | TAXE312 | | |
| SWAT | TAXE313 | | |
| NASA Biploar | TAXE314 | | |
| Other | TAXE315 | | |
| Questionaire | TAXE32 | | |
| Interviews | TAXE33 | | |
| Other | TAXE34 | | |
| Physiological | TAXE4 | C | 1 |
| Heart rate | TAXE41 | C | 10 |
| Heart rate (0.1 Hz.) | TAXE411 | C | 1 |
| Eye movements | TAXE42 | | |
| Respiration | TAXE43 | | |
| Blood Pressure | TAXE44 | | |
| GSR (Skin) | TAXE45 | | |
| EMG (Muslce) | TAXE46 | | |
| EEG (Brain Act.) | TAXE47 | | |
| EP (Evoked Pot.) | TAXE48 | | |
| Body Fluid | TAXE49 | | |
| Other | TAXE40 | | |

WORKLOAD CHARACTERISTICS (WC)

| | | | |
|---|---|---|---|
| Type - Mental (TM) | WCTM1 | C | 1 |
| Degree | WCTM11 | C | 2 |
| Duration | WCTM12 | | |
| Type - Psysical (TP) | WCTP1 | C | 1 |
| Degree | WCTP11 | C | 2 |
| Duration | WCTP12 | | |
| Function (FUN) ** | | | |
| Navigation | WCFUN1 | C | 10 |
| Communications | WCFUN2 | | |
| Command decision | WCFUN3 | | |
| Oper. & Monitor | WCFUN4 | | |
| Collision avoid | WCFUN5 | | |
| Path control | WCFUN6 | | |
| | WCFUN7 | | |
| | WCFUN8 | | |
| | WCFUN9 | | |
| | WCFUN0 | | |
| Factors (FAC) | | | |
| Normal Oper | WCFAC1 | C | 3 |
| Time Pressure | WCFAC2 | | |
| Abnormal | WCFAC3 | | |
| Specify | WCFAC3S | C | 25 |

TYPE of SUBJECT (TYPES)

| | | | |
|---|---|---|---|
| Expert | TYPES1 | C | 4 |

| | | | |
|---|---|---|---|
| Novice | TYPES2 | | |
| Student | TYPES3 | | |
| Other | TYPES4 | | |

## TASK DESCRIPTION (TASK)

| | | | |
|---|---|---|---|
| Task 1 description | TASK1 | C | 23 |
| Discrete | TASK11 | C | 3 |
| Paced | TASK12 | | |
| Continuous | TASK13 | | |
| - Response Form (RF) | | | |
| Verbal | TASKRF11 | C | 4 |
| Discrete motor | TASKRF12 | | |
| Cont. motor | TASKRF13 | | |
| Other | TASKRF14 | | |
| - Response Measure (RM) | | | |
| Time | TASKRM11 | C | 4 |
| Accuracy/error | TASKRM12 | | |
| Event | TASKRM13 | | |
| Other | TASKRM14 | | |

---

| | | | |
|---|---|---|---|
| Task 2 description | TASK2 | C | 23 |
| Discrete | TASK21 | C | 3 |
| Paced | TASK22 | | |

| | | | |
|---|---|---|---|
| Continuous | TASK23 | | |
| - Response Form (RF) | | | |
| Verbal | TASKRF21 | C | 4 |
| Discrete motor | TASKRF22 | | |
| Cont. motor | TASKRF23 | | |
| Other | TASKRF24 | | |
| - Response Measure (RM) | | | |
| Time | TASKRM21 | C | 4 |
| Accuracy/error | TASKRM22 | | |
| Event | TASKRM23 | | |
| Other | TASKRM24 | | |

---

| | | | |
|---|---|---|---|
| Task 3 description | TASK3 | C | 23 |
| Discrete | TASK31 | C | 3 |
| Paced | TASK32 | | |
| Continuous | TASK33 | | |
| - Response form (RF) | | | |
| Verbal | TASKRF31 | C | 4 |
| Discrete motor | TASKRF32 | | |
| Cont. motor | TASKRF33 | | |
| Other | TASKRF34 | | |
| - Response Measure (RM) | | | |
| Time | TASKRM31 | C | 4 |
| Accuracy/error | TASKRM32 | | |
| Event | TASKRM33 | | |
| Other | TASKRM34 | | |

| | | | |
|---|---|---|---|
| Task 4 description | TASK4 | C | 23 |
| Discrete | TASK41 | C | 3 |
| Paced | TASK42 | | |
| Continuous | TASK43 | | |
| - Response Form (RF) | | | |
| Verbal | TASKRF41 | C | 4 |
| Discrete motor | TASKRF42 | | |
| Cont. motor | TASKRF43 | | |
| Other | TASKRF44 | | |
| - Response Measure (RM) | | | |
| Time | TASKRM41 | C | 4 |
| Accuracy/error | TASKRM42 | | |
| Event | TASKRM43 | | |
| Other | TASKRM44 | | |

METRIC QUALITIES (METRIC)

| | | | |
|---|---|---|---|
| Indiv. Differences | METRIC1 | C | 1 |
| Reliability | METRIC11 | C | 3 |
| Stability | METRIC12 | | |
| Other S diff | METRIC13 | | |
| Comparitive Sensit. | METRIC2 | C | 1 |
| Validity | METRIC3 | C | 1 |

| | | | |
|---|---|---|---|
| - Task to task | | | |
| Sub to sub | METRIC31 | C | 3 |
| Sub to obj | METRIC32 | | |
| Obj to obj | METRIC33 | | |
| - Type | | | |
| Content | METRIC34 | C | 3 |
| Construct | METRIC35 | | |
| Predictive | METRIC36 | | |
| Reliability | METRIC4 | C | 1 |
| Test - retest | METRIC41 | C | 4 |
| Split half | METRIC42 | | |
| Alternate forms | METRIC43 | | |
| Interrater | METRIC44 | | |

KEYWORDS (KEYTERM)

| | | | |
|---|---|---|---|
| KEY1 | KEYTERM1 | C | 30 |
| KEY2 | KEYTERM2 | C | 30 |
| KEY3 | KEYTERM3 | C | 30 |
| KEY4 | KEYTERM4 | C | 30 |

COMMENTS (COMMENT)

| | | | |
|---|---|---|---|
| Comment | COMMENT1 | C | 75 |

| | | | |
|---|---|---|---|
| Comment | COMMENT2 | C | 75 |
| Comment | COMMENT3 | C | 75 |
| Comment | COMMENT4 | C | 75 |
| Comment | COMMENT5 | C | 75 |
| Comment | COMMENT6 | C | 75 |

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Due to the limitation of a maximum of 128 fields in dbase III, a number of the characteristics had to be combined into a single field. The rules for this are based on the estimated probability of searching within a category. For example, Math models from the analytic taxonomy is a single field. The subcategories under math models are a combined field. If Math Models is entered (something other than blank) then you would be asked for the subcategories and these would be stored in TAXA41, in order. Thus, if Infomation Theoretic were the only subcategory, the contents of TAXA41 would look like this '.X.'. (Periods are put into the field when there is no entry. This is done so that if the whole field is printed it is easy to tell where the entry is.)

In the main table, combined entries are indented. Those fields which are combined into another label are blank for field type and length. The example below illustrates this. TAXA42 and TAXA43 are combined into TAXA41.

| | | | |
|---|---|---|---|
| Math Models | TAXA4 | C | 1 |
| Manual | TAXA41 | C | 3 |
| Info Theor. | TAXA42 | | |

Other TAXA43

Further, as the indentation above represents, an indented field will be empty automatically if the main field is blank. Thus, if TAXA4 is blank, the subcategories will also be empty e.g., TAXA41 would be '...'.

In a case where there are subsubcategories, these are listed in the the logical order following the subcategory driving it. TAXE31 has a subcategory of TAXE311, ...,. TAXE311 is a field containing these entries and follows TAXE31 on the dbase III file listing. TAXE32, etc. is stored in field TAXE31.

Figure E-2

WORKLOAD REVIEWER WORK SHEET

This form will be used until our online:

database system is available:

Instructions to Reviewer:

If Item No. below is blank, please provide full reference, including all authors, title, journal or volume, pages, publisher, year, etc. so we can enter the reference into our database, along with your review.

We have endeavored to design this form to be as easy to use as possible. In the following, please check those items which are relevant to the paper being reviewed. MORE than one item in a category may be appropriate, so please check all appropriate items.

Try to be as complete as possible. Remember, others will be using the information you submit.

For articles which are difficult to locate, it would be appreciated if you would provide a copy for our files.

## REVIEWER WORK SHEET

Item No.: ________________ Author: ______________________________

(OWL database #) (Last name, initials)

Reviewer: ____________________ Rating: 0 1 2 3 4 5 6 7 8 9 10

(Reviewers subjective evaluation)

REFERENCE:

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

REPORT NATURE or TYPE:

__ DoD (Policy & Implementation)

__ Theoretical

__ Review

__ Bibliographic

__ Methodological

__ Laboratory Experimentation

__ System Application

Specific System: __________________________

FIDELITY:

__ Actual system __ Simulation __ Applied Lab __ Basic lab 3

TAXONOMY

Analytic Procedures

__ Expert opinion
__ Comparison
__ Simulation models
__ Math models — __ Manual control models
__ Information theoretic model
__ Other
__ Task analytic methods

Empirical Procedures

__ Primary task (How many?) — __ Performance related
__ Strategy related
__ Other
__ Secondary task (How many?) — __ Subsidiary task
__ Probe task
__ Dual task
__ Other
__ Subjective scales — __ Rating scales
__ CH __ MCH __ SWAT
__ NASA biploar __ Other
__ Questionaires/Survey
__ Interviews
__ Other
__ WCI/TE
__ Physiological & eye movements — __ Heart rate
__ HR (0.1 Hz)
__ Eye movements
__ Respiration
__ Blood pressure
__ GSR (skin)
__ EMG (muscle)
__ EEG (brain activity)
__ EP
__ Body fluid
__ Other

REVIEWER WORK SHEET

WORKLOAD CHARACTERISTICS:

Type __ Mental __ Degree __ Duration
__ Physical __ Degree __ Duration

Function __ Navigation __ Communications __ Command decisions
__ Operation and monitoring __ Collision avoidance
__ Path control __
__ Maintenance __
__ Ground vehicles __ Aviation

Factors __ Normal operation
__ Time pressured
__ Abnormal operation Specify ______________________________

TYPE OF SUBJECT:
__ Expert __ Novice __ Student __ Other

TASK TYPE: e.g., Tracking, visual search, reaction time, etc.

No. 1:________________ __ Discrete __ Paced __ Continuous
Response Form: __ Verbal __ Discrete motor __ Cont. motor __ Other3
Response Measure __ Time __ Accuracy / Error __ Event __ Other

No. 2: ________________ __ Discrete __ Paced __ Continuous
Response Form: __ Verbal __ Discrete motor __ Cont. motor __ Other
Response Measure __ Time __ Accuracy / Error __ Event __ Other

No. 3: ________________ __ Discrete __ Paced __ Continuous
Response Form: __ Verbal __ Discrete motor __ Cont. motor __ Other
Response Measure __ Time __ Accuracy / Error __ Event __ Other

No. 4: ________________ Discrete __ Paced __ Continuous
Response Form: __ Verbal __ Discrete motor __ Cont. motor __ Other
Response Measure __ Time __ Accuracy / Error __ Event __ Other

## REVIEWER WORK SHEET

METRIC QUALITIES:

| | |
|---|---|
| __ Individual differences | __ Reliability |
| | __ Stability |
| | __ Other subject differences |
| __ Comparative sensitivity | |
| __ Validity measures | __ Subjective to subjective |
| Task to Task -> | __ Subjective to objective |
| | __ Objective to objective |
| Type -> | __ Content |
| | __ Construct |
| | __ Predictive |
| __ Reliability | __ Test - re-test |
| | __ Split half |
| | __ Alternate forms |
| | __ Inter rater |

KEYWORDS (You need not repeat words from title or words representing items you have checked.)

______________________ ______________________

______________________ ______________________

COMMENTS:

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

Draft Technical Report 2075-2

# OPERATOR WORKLOAD (OWL) ASSESSMENT PROGRAM FOR THE ARMY:

## RESULTS FROM REQUIREMENTS DOCUMENT REVIEW AND USER INTERVIEW ANALYSIS

22 May 1987


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Task Report
Contract No. MDA903-86-C-0384
Item No. 0002AD

## EXECUTIVE SUMMARY

This report is one of a series describing a program for the development and validation of a methodology for estimation and evaluation of operator workload (OWL) in Army systems. It presents the results of Task 2 of Analytics' contract with the Army Research Institute (ARI) to "Identify Army Requirements Regarding OWL, Select Specific Army Systems to Analyze , and Provide Outline of OWL Products". Included are the results of component subtasks: (2.1) Review Army Requirements and Reports, (2.2) Assess User Needs, (2.3) Outline Final Products, and (2.4) Select Prototype Army Systems to Evaluate. The overall purpose of this report is to characterize existing and future Army requirements and needs for OWL assessment, to tailor the OWL program to meet these requirements and needs, and to identify emerging Army systems that are appropriate candidates for exercising families of OWL assessment techniques.

Based on the review of Army documents and regulations, there seemed to be a void in specific guidance concerning the implementation of OWL assessment during the Materiel Acquisition Process (MAP). Such lack of specific guidance concerning OWL assessment was further substantiated in our interviews as well as from questionnaire data with Army personnel who play integral roles during the MAP. Our assessment of these findings has resulted in tailoring the proposed products (e.g., Outlines of OWL Handbooks and Pamphlet) to meet the apparent need for OWL guidance throughout the MAP. In addition, recommendations are offered in the report for integrating our efforts with existing Army programs (e.g., MANPRINT) to assure that OWL receives adequate consideration throughout the MAP. With respect to selecting prototype Army systems to evaluate, candidate systems are offered that allow a wide-range of OWL techniques to be employed as well as providing opportunities to make substantial and positive contributions toward impacting the design of these systems .

## TABLE OF CONTENTS

# 1. INTRODUCTION

This report is one of a series describing a program for the development and validation of a methodology for estimation and evaluation of operator workload (OWL) in Army systems. It presents the results of Task 2 of Analytics' contract with the Army Research Institute (ARI). The components comprising this task are:

- Review Army Requirements
- Assess User Needs
- Outline Final Products
- Select Prototype Army Systems to Evaluate

The overall purpose of this report is to: Present Army requirements and needs as obtained throughout document review and interviews regarding OWL issues and concerns, outlines of final products based on those requirements and needs, and to suggest emerging Army systems for OWL evaluation.

## 1.1 Overview of Program Progress

The OWL program is one of several focusing on the practical problem of determining what the Army can and should do to assure that systems can be adequately operated by prospective personnel. As new technologies are implemented with greater degrees of computer-interaction, there is growing concern questioning the ability of soldiers to operate these systems. With regard to OWL, pertinent questions include, "How much information processing, decision making and other cognitive tasks can system operators handle?" and "Under what time and other limitations may operators continue to function before overload and performance degradations occur?" These OWL questions need to be addressed during system development to avoid marginal or inoperable systems.

The primary focus of the present program is with single operator workload. For present purposes, OWL may be thought of as a representation via predictive and empirical assessment techniques of a human operator's relative limitation in the capability to perform work. Here, relative limitation implies a functional relation between (1) actual operator performance in the context of mission requirements and (2) the operator's ultimate performance capability. Our emphasis is on the cognitive, perceptual and psychomotor

aspects of workload, although it is recognized that there are physical workload issues more associated with maintainer tasks (lifting, carrying, etc.).

A necessary step in the process of providing practical assistance to the Army is to understand current procedures and requirements for addressing operator workload in the Materiel Acquisition Process (MAP). This understanding will form the basis for development of useful guidance for the Army community. To gain this understanding two avenues were employed. First, the procedural aspects of the Army MAP were reviewed via written documents. Second, discussions were conducted with military and civilian personnel within the Department of the Army (DA) to further understanding of their roles in the MAP, their current methods of addressing OWL, and their thoughts on what could be provided to them that would be most useful in their jobs. This process of understanding and its results are discussed later in the report.

From the comments and suggestions gathered, draft outlines of the three handbooks have been developed for this report. The handbooks which will be developed during a later effort (Task 5) will form the basis of the guidance provided to the Army users for addressing operator workload The guidance will result from a critical review of the current scientific literature concerning definition, prediction, measurement and evaluation of workload which will be accomplished as part of the follow-on in Task 3. The suggested guidance and methodologies will be validated subsequently by application to specific Army systems (Task 4). However, the systems have been chosen as part of the present effort so that familiarization with system specifics and necessary coordination with the appropriate Army organizations can begin. As will be seen, the task of choosing prospective systems was assisted by the interview process; those most familiar with what systems are most appropriate were some of the same individuals with whom we were speaking about OWL requirements and needs. The application of the techniques to the three selected systems will serve as the means to validate the practical approach being devised as well as providing benefits for the systems and the Army.

## 1.2 Organization of Report

The body of this report presents the results of Task 2. Section 2, in particular, discusses the review of documents that describe the Army Materiel Acquisition Process and how operator workload is currently addressed within the MAP. Subsequently, the

results of the interviews of members of the Army community concerning their roles and responsibilities (both current and projected) in the MAP and their viewpoints concerning OWL are presented in Section 3. In Section 4, the concepts and rationale for the final products are discussed and the product outlines are presented. The descriptions of Army systems that have been selected for assessment and validation of OWL assessment techniques are presented in Section 5. Finally, Sections 6 and 7 discuss other progress to date as well as plans for future tasks of the OWL program.

# 2. REVIEW OF ARMY REQUIREMENTS

## 2.1 Introduction

The Army maintains a continuous effort to field the most capable force possible. When changes in doctrine, organization or training cannot eliminate identified deficiencies, then a decision may be made to eliminate the deficiencies through equipment acquisition (i.e., procuring hardware systems). The process by which new equipment is conceived, designed, developed and procured is given in regulations, directives, and other documents.

As part of the OWL project effort, a review of the documents and regulations that drive Army materiel acquisition was performed. The review was one method to gain an understanding of the Army system of materiel acquisition -- the way the requirements for materiel are developed, the information needed to develop requirements, how the requirements are translated to hardware design and development, and the roles of members of the Army community who manage or perform these tasks. The document review also was a means of identifying guidance inconsistencies and voids.

This chapter describes the approach used to understand the Army acquisition process, how the issue of OWL is currently addressed in the process, what documents provide guidance and where we see OWL issues potentially being addressed in the acquisition process.

## 2.2 Approach

A series of documents were reviewed for two major purposes. First, we needed to assure a comprehensive understanding of the documented Army Materiel Acquisition Process (MAP). For this purpose, a detailed review of both directly and indirectly relevant documents was conducted to identify (1) if and where OWL issues are considered and, (2) how they are currently addressed.

The process was an iterative one -- as more relevant documents were identified, ones read previously were reread for increased information and understanding. Additionally, the interview and questionnaire methodology employed to assess Army user

needs (see Section 3.) yielded information that added to our understanding of both the MAP and associated issues regarding the assessment of OWL. The interviews provided for iterative document review as well as further contacts.

The following sections, then, will present discussion of our review. The discussion of the Army Materiel Acquisition Process in Section 2.3 deals with the process as described in Army Regulations (ARs) and other written documents. Of particular importance is the recent emphasis on the Army Streamlined Acquisition Process (ASAP) and other acquisition alternatives, such as Non-developmental Items (NDI) and product improvements (P3I, PIP). Section 2.4 describes the few places in the reviewed documents where OWL is mentioned. In addition, the review was expanded to include mention of Human Factors Engineering (HFE) and MANPRINT where OWL concerns may be expected to be of greatest interest and importance. Finally, several conclusions are drawn from the document review of OWL and recommendations are made.

Some documents are more important than others and specific reference will identify those when appropriate. In all cases, the documents reviewed were the latest editions that could be obtained. It is noteworthy, as can be seen by the effective dates of many of the ARs, much guidance has been recently revised and published. In one sense then, this discussion is based on guidance available within the present slice of time. However, the general process of identifying requirements and developing/acquiring equipment to fulfill the requirements remains essentially unchanged. The discussions that follow will make specific reference to the latest guidance available, but will also include an overall perspective of the Army MAP and OWL issues in MAP.

## 2.3 The Army Materiel Acquisition Process

### 2.3.1 Introduction

There has been a great deal of innovation and adjustment in the acquisition process during this decade. Incorporation of the recommendations of bodies such as the Packard Commission have resulted in many changes in the way the Department of Defense and the Army approach developing and fielding new materiel. Four broad categories of acquisition methods are recognized. These are:

- Traditional Process
- Army Streamlined Acquisition Process (ASAP)
- Non-Development Items (NDI)
- Product Improvement.

The traditional process is described in a degree of detail which may seem out of proportion to its modern application. This approach is taken because most persons with some experience in materiel acquisition are familiar with the traditional process and use it for comparisons. The other development methods are described using the traditional process as a baseline. This section describes the Army Materiel Acquisition Process (MAP) and projects how OWL considerations could or should be integrated into the MAP.

Major reference sources for this section are AR 70-1, Systems Acquisition Policy and Procedures, AR 71-9, Materiel Objectives and Requirements and DARCOM (now AMC) / TRADOC Pamphlet 70-2, Materiel Acquisition Handbook. Major implementing regulations in specific disciplines, such as AR 70-10, Test and Evaluation, and AR 602-2 MANPRINT have also been useful sources. AMC Regulation 70-52, System Engineering, is a relatively new publication which may have impact on incorporating OWL enhancements to new or improved materiel. It provides renewed emphasis to the importance of the systems engineering process in materiel development. Department of the Army Pamphlet 11-25, Life Cycle System Management Model for Army Systems, has also been useful. This latter reference is, however, over ten years old and must be used with great caution. Many of the features of the model have been significantly impacted by recent changes in the acquisition process. For instance, the MANPRINT program has had a considerable amount of influence on the treatment of manpower, training, human factors and safety issues. Some caution must also be used in applying DARCOM/TRADOC Pamphlet 70-2.

### 2.3.2 The Traditional Materiel Acquisition Process

#### 2.3.2.1 Overview (AR 70-1,Pam 70-2)

The Traditional acquisition process is divided into five phases. They are the (1) Program Initiation, (2) Concept Exploration, (3) Demonstration and Validation, (4) Full Scale Development (FSD), and (5) Production and Deployment Phases. Production and Deployment may be divided into Low Rate Initial Production and a full Production and

Deployment Phase. Each succeeding phase takes a materiel requirement from a broad concept to successively more precisely specified, producible and supportable materiel solution to the Army's operational needs. The traditional process typically consumes about 11 to 15 years from program initiation to fielding.

OWL considerations and trade-offs should be made early in this life cycle. A commonly accepted rule of thumb holds that 70 percent of system life cycle costs are set at or before the system proceeds into the Demonstration and Validation Phase ( Advanced Development ). Paralleling this is the observation of a similar accelerating decline in design flexibility. Figure 2.3.2-1 illustrates the traditional process and where OWL evaluations and predictions may be used most appropriately. OWL consideration must be made in the early phases of development because the costs of modifying design later accelerate and options similarly decline as the system proceeds further into the MAP.

#### 2.3.2.2 Program Initiation (AR 70-1, AR 71-9, PAM 70-2)

Activities which result in program initiation activities can be divided into two broad categories. These are mission and operations oriented activities and science and technology oriented activities. Mission and operations oriented activities include threat assessments, conduct of Mission Area Analyses (MAA), development of long range plans such as the Battlefield Development Plan (BDP) and the Mission Area Materiel Plan (MAMP), and preparation of the DA Long Range Research Development and Acquisition Plan (LDRRDP).

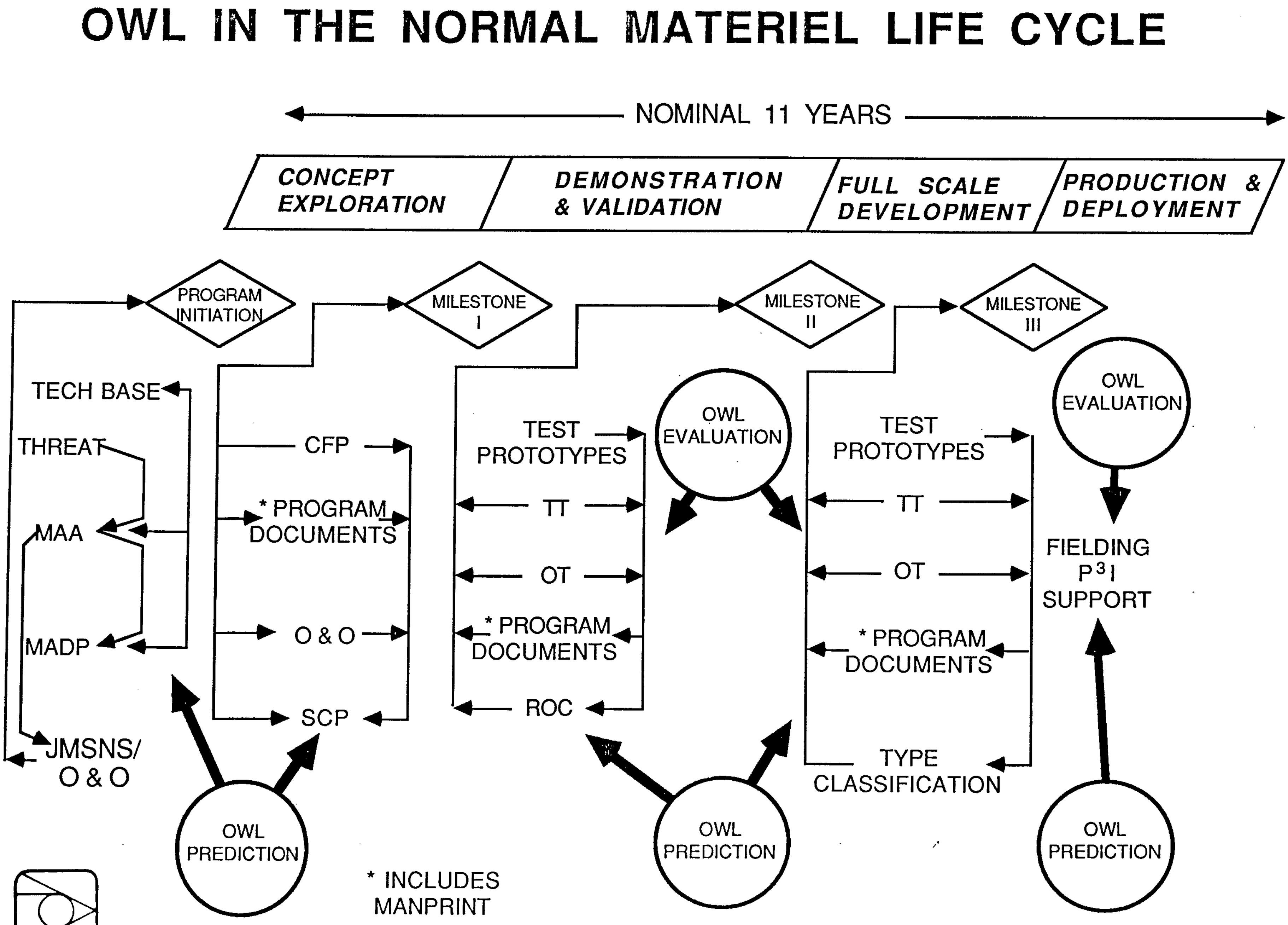


Figure 2.3.2-1 OWL Considerations in the Traditional MAP

Science and technology oriented activities include basic and exploratory research and other technical base activities which lead to new or improved technological capabilities. The operations and mission oriented activities may lead to the development and submission of a Justification for Major Systems New Start (JMSNS), upon which a major DoD program may be based. An Operational and Organizational Plan (O&O Plan), is the basis for initiating a designated acquisition program (DAP) at the Department of Army level or non-major development program at levels below DA. The O&O Plan is also a part of the JMSNS. OWL considerations have potential contributions to all these activities. For example, basic and exploratory research, and technical base programs may directly address OWL issues. Mission Area Analyses (MAAs) may conclude that operational work load deficiencies may constitute future program drivers. The O&O plan may be constrained by OWL considerations.

The mission oriented activities include the thirteen specific MAAs which have been conducted and are periodically updated by the US Army Training and Doctrine Command (TRADOC). These analyses provide an in-depth examination of the Army's ability to perform its fundamental combat missions (e.g. Close Combat, Fire Support, Air Defense, NBC, etc.). OWL considerations may limit specific operational capabilities addressed within given mission areas. These would be expected to be statements of OWL limitations based on evaluation of existing capability.

The BDP and MAMP are broad examinations of the Army's operational and materiel capabilities. They are based on the MAA and prioritize future program efforts based on the DA LRRDAP. If a materiel solution is considered appropriate to address a mission area deficiency, that solution is supported in an O&O Plan. The O&O plan may be prepared as a stand-alone document or may be an attachment to the JMSNS. OWL considerations play an important role in developing the O&O plan. The O&O plan (Appendix C, AR 71-9) describes how a system will be integrated into the force structure, and deployed, operated and supported during both peace time and war time. It ultimately supports the preparation of detailed integrated logistic support planning, basis of issue planning, and broad personnel planning. MANPRINT considerations and personnel impacts are a specific section within the O&O Plan. Assessment of these personnel impacts need to be supported by OWL predictions and evaluations for similar existing systems.

Technical base activities include basic research and exploratory development which address questions which impact on future operational capabilities. OWL issues need to be

addressed within the framework of these research programs. Technical base activities are prioritized and funded in accordance with Science and Technology Objectives (STOs) which are established and prioritized in the HQ DA LRRDAP. The STOs are based on operational deficiencies noted in MAAs.

Program initiation results when it is recognized that an operational deficiency exists and it is likely that a materiel solution will be effective. Typically, a Special Task Force (STF), Special Study Group (SSG) or acquisition team is formed on approval of the O&O Plan or JMSNS. Secretary of Defense guidance may be established for major programs in a Program Decision Memorandum (PDM). The PDM provides broad program guidance from the DoD level for systems for which a JMSNS is required. The STF/SSG or Acquisition Team carry the program responsibilities until the program enters the Concept Exploration Phase.

2.3.2.3 Concept Exploration (AR 70-1, AR 71-9, AMC Reg 70-52, Pam 70-2, AR 602-2)

During concept exploration, technical alternatives to meeting the stated material need and supporting that system are identified and explored. The competing alternatives include incorporation of new technology, adoption of non-development items (NDI), and product improvement of existing hardware. Market surveys are conducted, bread board and experimental prototypes are developed and tested, and information regarding development risks and program alternatives are developed and assessed. Final system concepts are ultimately selected and plans addressing training, logistics, and future testing are developed. An Acquisition Strategy (AS) is developed which guides the conduct of the future program.

The concept exploration phase may be the most critical for the application of OWL concepts. Trade offs addressing technical approaches and training and support approaches will impact on virtually all future related development activities. OWL issues addressed in the trade off determination (TOD), trade off analysis (TOA) and development of the best technical approach (BTA) will become embedded in the program for its entire life. OWL considerations will also impact on other studies and analysis conducted during this phase. System engineering activities commence and serve as a significant tool for integrating OWL requirements into the system. Update of the O&O plan and development of cost and operational effectiveness analysis, development of base line cost estimates and independent

parametric cost estimates will all be impacted by OWL considerations. Typical concept formulation activities are described briefly with comments on their relationship to operator workload issues. These activities include :

- O&O Plan -- The previously developed O&O Plan is revised. Requirements stated within the O&O Plan should be based on an understanding of potential OWL impacts. OWL assessments based on similar systems may be employed in developing the plan.
- Concept Formulation Package -- The CFP consists of the Trade Off Determination (TOD), the Trade Off Analysis (TOA), the Best Technical Approach (BTA), and the Cost and Operational Effectiveness Analysis (COEA). These analyses are packaged as a part of the CFP under a cover letter which summarizes essential system features to include MANPRINT requirements (Appendix E, AR 71-9), and performance characteristics.
- Trade Off Determination -- The TOD establishes viable trade offs for the suggested approach in pursuing the development program. It includes life cycle costing and scheduling information. ILS and MANPRINT requirements are included in issues which must be addressed within the TOD. OWL predictions regarding one or more trade off alternatives may be required.
- Trade Off Analysis -- TOA is prepared jointly by the combat developer and material developer. TOA serves to select the best technical approach based on the alternatives presented in the trade off determination. Again, MANPRINT and ILS requirements are essential trade offs. OWL predictions which consider system impacts resulting from OWL considerations may be important in completing the TOA.
- Best Technical Approach -- BTA is prepared jointly by the materiel and combat developer. It documents the BTA to include ILS and MANPRINT concepts based on the results of the TOD and TOA. The results of previous OWL predictions are considered in formalizing the BTA.
- Cost and Operational Effectiveness Analysis -- The COEA is prepared by the combat developer. It examines the cost and operational effectiveness of competing alternatives. All important systems aspects should be considered in addressing COEA to include OWL. OWL predictions and the results of OWL evaluations on bread board and brass board prototypes can provide important information.
- Bread Board/Brass Board Tests -- Bread board and brass board prototypes are normally fabricated and tested during the course of concept evaluation . Early OWL evaluations against these prototypes will provide an important baseline for future OWL predictions and the development of future OWL evaluation methodology.
- Acquisition Strategy -- The AS is the basic program plan for the development program. It is prepared by the material developer in coordination with the other members of the acquisition team. It provides guidance on tailoring the acquisition process for the specific

development and highlights potential risks and plans to reduce or eliminate risks. MANPRINT is specifically addressed in the AS (AR 70-1, paragraph 5-2b). OWL is an issue to be considered under MANPRINT analyses.

- System Safety Program Plan -- Safety and health hazard assessment issues have been addressed and identified for further resolution during the development process. These measures are addressed in the SSPP. Potential OWL issues may result from predictive analyses. OWL evaluation may result from bread board and brass board prototype tests. Considerations may include operational constraints, training requirements and restrictions.
- Integrated Logistics Support -- Integrated logistics support planning is initiated. This includes issues such as maintenance planning, manpower and personnel requirements, training operating personnel, and requirements for training devices. ILSPs prepared during the concept formulations phase may include the results of investigations based on performance data from deployed systems.
- Training Plans -- Training plans developed during the concept exploration phase address alternative training concepts. They are designed to highlight critical training areas for consideration during the balance of the development process, therefore contributing to the ultimate system availability, maintainability, and operational capability. Human factors considerations in general, and OWL considerations in particular are important training planning drivers. OWL predictions based on OWL evaluations of early bread board and brass board, and similar systems currently in the field are important sources of data for the preparation of training plans. These plans include assessment of appropriate training methods, media, training devices, skill qualification, evaluation procedures, and the need for training simulations.
- System MANPRINT Management Plan -- The SMMP is the management document that describes MANPRINT concerns and tasks and analyses that need to be conducted during the acquisition to ensure consideration of manpower, personnel, training, human factors engineering, system safety, and health hazard assessment. These issues are addressed and resolved or identified for resolution during following phases. OWL assessments of existing hardware may be useful in comparative analyses. The SMMP is initiated and maintained by the combat or training developer and is updated throughout the acquisition process (AR 602-2). (See Section 2.4.3 for further discussion of the SMMP).
- Test and Evaluation Master Plan -- Test and Evaluation Master Plan (TEMP) developed during the concept formulation provides the foundation for development and operational testing throughout the balance of the program. The TEMP provides the frame work for showcasing critical development and operational issues which need to be addressed during future testing. Operational issues which may be addressed during development testing, and the expansion of the development test data base during operational testing are important issues for consideration within the TEMP. Critical OWL issues (such

as those identified in the SMMP) are highlighted in conjunction with other MANPRINT and human factors related test issues.

- System Engineering Management Plan -- The System Engineering Management Plan (SEMP) is prepared in accordance with AMC Regulation 70-52. The SEMP will provide a framework for the integration of system requirements including MANPRINT and OWL considerations Application of sound system engineering principles, based on the SEMP, will be a required feature throughout the life of the program.
- System Concept Paper -- The SCP summarizes the activity of the Concept Exploration Phase and is the basis for obtaining approval to proceed to the next phase of development. Although the SCP is very brief, not exceeding 12 pages, it is a key document in the Materiel Acquisition Decision Process (MADP). OWL issues would not normally be expected to be highlighted within the SCP. However, critical OWL issues may be highlighted under the MANPRINT or HFE paragraphs in the Acquisition Strategy (Annex F).

Programs in the Concept Explanation phase may be under a program manager, may continue to be managed by the SSG/STF, or may be managed by an acquisition team appointed by the developing agency. TRADOC will typically follow the program through an appropriate TRADOC Systems Manager (TSM) with input from the Combat Development and Training Development Directorates of the proponent school.

#### 2.3.2.4 Demonstration and Validation Phase ( AR 70-1, AR 70-10, AMC Reg 70-52, Pam 70-2 , AR 602-2)

The Demonstration and Validation Phase is conducted to verify preliminary designs and engineering, and to accomplish the necessary planning and trade offs to reduce risks in future development and fielding. ILS and MANPRINT issues are addressed early-on (AR 70-1, paragraph 3-5a). Emphasis includes conducting trade offs among system characteristics, manpower, personnel, training, and support concepts. Other important tasks include preparation of the Required Operational Capability documentation and training device requirements. User participation is important during testing in order to prove out the O&O concept. OWL concepts and considerations are applied throughout this phase of development. It is essential to thoroughly apply OWL evaluation capabilities during this phase in order to insure that OWL related trade offs are thoroughly understood. The cost of modifying designs for the sake of OWL enhancements becomes progressively more expensive as the program proceeds to full scale development.

The demonstration and validation phase features procurement of advanced development prototypes for testing during development and operational tests . Frequently, competing prototypes will be developed, fabricated, and tested. The advanced development prototypes are designed based on functional requirements and are consistent with the Best Technical Approach articulated in the Concept Formulation Package. Technical and operational tests provide an excellent forum for validating OWL predictions made during the Concept Formulation Phase. It is important to ensure that OWL issues are addressed during these tests in order to develop a clear understanding of OWL issues which need be addressed in future development and production. Typical advanced development activities are described briefly with comments on their relationship to operator workload issues. These activities include:

- Advance Development Contract -- Advanced development prototypes are based on the preferred alternatives studied during concept formulation. Frequently, two or more competing prototypes will be procured for development and operational test and evaluation. OWL specialists should be involved in developing the technical data package for the Advanced Development Contracts and in evaluating the resulting proposals. The advanced development prototypes provide an efficient form for addressing the impacts and potential solutions to OWL problems in fielded items. OWL related designs features, OWL studies, and OWL evaluations may be all addressed within the frame work of the Advanced Development Contracts.
- Technical and Operational Tests -- Technical and Operational tests are conducted on advanced development prototypes and address critical issues established in the TEMP. Both government and contractor developed test data is used to address these issues. OWL specialists participate in or closely follow the conduct of these tests. In those cases where specific OWL issues are being evaluated within those test programs, OWL specialists will develop test procedures, collect or supervise collection of OWL related data, and report and evaluate the results of those tests. Frequently the developer and user address respective critical issues during the same test procedures. Close coordination with all individuals on the test team will enhance the efficient and effective collection of OWL related data. Established OWL evaluation methodology, or specific methodology developed during previous development phases, will be applied during technical and operational tests.
- ILSP Updates -- The ILSP, prepared during the Concept Formulation Phase, receives a complete update during demonstration and validation. This update is based on the results of testing. The updated ILSP examines support planning concepts, establishes a baseline support concept, identifies support parameters, and examines potential supportability problems. Logistic systems and resource constraints, and recommended reliability and maintainability parameters, are formulated.

- Training Support Planning Update -- The plans for training support are updated by the trainer and the material developer in coordination with the combat developer and logistician. This update is done in conjunction with preparation of the tentative qualitative and quantitative personnel requirements information (TQQPRI) which has significant OWL impact. The plans for training support will include plans for new equipment training. Training support plans establish the baseline for future training during full scale development, initial production and fielding, and subsequent support of the system in the field. Potential or identified OWL problems may be addressed through training.
- Tentative Qualitative and Quantitative Personnel Requirements Inventory -- The TQQPRI is prepared by the material developer. The TQQPRI is based on human factors studies, logistics support analysis, development of a system training strategy, and behavioral research. It describes personnel duties, tasks down to work units, performance standards, the basis for manpower authorization factors, recommended Military Occupational Specialties (MOS) to include skill levels, and recommended organizations. The TQQPRI, in conjunction with the Integrated Logistics Support Plans, are essential in developing hardware basis of issue plans (BOIP), training device requirements, and other training in support issues. The TQQPRI provides the most current information concerning numbers and qualifications of personnel required for employment support and maintenance of the system.
- Tentative Basis of Issue Plan -- The TBOIP is prepared by the combat developer in consideration of studies conducted by the combat developer and the TQQPRI. It serves as the basis for future development of how the system will be distributed and supported within the Army. The TBOIP is developed on the basis of the best available information.
- Training Device Requirement -- TDR requirements are developed by the trainer in conjunction with development of training support plans and the TQQPRI. Training devices used during testing and future tests may also be useful tools in investigating OWL issues.
- Required Operational Capability -- The ROC establishes essential operational, RAM, technical, personnel and manpower, training, safety and health, human factors engineering, logistical, and cost information. It is used as a basis for proceeding with full-scale development. Letter Requirements (LRs) are prepared for similar purpose for low dollar value items. MANPRINT issues are addressed in a specific section (Paragraph 8) of the ROC. Operational trainability and the technical feasibility of the proposed system is also addressed. OWL inputs to a ROC (or a LR) are based on the results of previous OWL evaluations and current OWL predictions. The most appropriate location for OWL inputs would be in the MANPRINT section.
- Safety and Health Hazard Assessment -- The Safety and Health Hazard Assessment is developed based on test results and other demonstration and validation phase activities. Results of OWL evaluations conducted during tests and potential OWL problems may be used in updating the Safety and Health Hazard Assessment.

- Human Factors Engineering Analysis -- The HFEA is conducted to identify any human factors problems associated with the system. Suitability of the system to proceed to the Full Scale Development Phase is established. Human factors issues, including OWL for resolution are highlighted.
- System MANPRINT Management Plan -- The SMMP is updated based on demonstration and validation phase results. Plans for future MANPRINT related activity are incorporated.
- Technical Data Package -- The technical data package (TDP) for a full-scale engineering development is a detailed specification for engineering development prototypes. The specifications must be in sufficient detail to insure delivery of hardware and software which is characteristic of that which may be delivered from production processes. Such detailed specifications may be useful in determining hardware design characteristics that impact OWL.
- Acquisition Strategy Update -- The AS developed during the Concept Formulation Phase is updated to support full-scale engineering development and subsequent production and fielding. MANPRINT issues, examined during the development of the original AS are re-examined, updated, and expanded. The results of OWL evaluations conducted during the validation phase and current OWL predictions are used as a basis for preparing OWL related inputs to the AS.
- Test and Evaluation Master Plan Update -- The TEMP is updated to reflect test and evaluation requirements for full-scale development, and production and fielding. OWL critical issues to be addressed during technical and operational testing and subsequent production related testing must be articulated in this TEMP update. OWL critical issues are based on OWL evaluation results from the tests and predictions made during the validation phase.
- Cost and Effectiveness Analysis -- COEA is updated based on the results of tests and studies conducted during the demonstration/validation phase. The resolution of OWL issues may have substantial impacts on COEA results. The results of OWL evaluations conducted during the validation phase and current OWL predictions are used as a basis for the COEA update.
- System Engineering Management Plan -- System Engineering activities continue in order to insure integration of required system features on a total system basis. The SEMP is updated to support full-scale development. These activities are a major tool for integrating MANPRINT in general and OWL considerations into the development program.
- Decision Coordinating Paper -- The DCP summarizes the results of the demonstration/validation phase, and provides a recommendation for proceeding with development of the system. It is a key document in the MADP for obtaining a decision to proceed to FSD. The DCP is not to exceed eighteen pages, excluding six annexes. The DCP includes a description of the alternatives considered during the demonstration/validation phase, and a description of the selected alternative to include the operational concept for the selected alternative.

Sustainability and economy of manpower are issues to be included in that discussion. The DCP also includes technological risks for the selected alternative and how those risks have been resolved in the demonstration/validation phase. OWL inputs to the DCP are based on OWL evaluations conducted during the demonstration/validation phase and current OWL predictions. The DCP includes the AS (Annex F) and its attendant MANPRINT/Human Factors section.

The Demonstration and Validation Phase is managed by a Project Manager, or by an acquisition team appointed from within the developing agency. DoD major programs and DAP will be conducted under a DOD or DA chartered Program Manager. TRADOC will typically continue to follow the major systems through an appropriate TRADOC Systems Manager (TSM) with input from the Combat Developments Directorate of the proponent school. IPR programs which are not under project or product managers will be managed by an acquisition team appointed by the developing agency.

2.3.2.5 Full-Scale Development (AR 70-1, AR 70-10, AMC Reg 70-52, Pam70-2 )

Full Scale Development provides an opportunity to completely evaluate the system in the form expected to be fielded. Systems which successfully complete full scale development are type classified as standard and are procured for issue to the field. The total system is normally prototyped, tested and evaluated, to include all support systems and software. These include simulators, training devices, computer equipment, training, and maintenance manuals. OWL evaluation expertise is required to ensure that OWL issues have been addressed in the full scale development prototypes.

There is limited opportunity to make changes in the system which will enhance OWL performance during this phase of development. Essential changes may be considered if there is a significant OWL problem. However, changes to any part of the system tend to cascade throughout the system, to include software and manuals. As a result, changes are expensive and time consuming. Most changes not demonstrated as essential for meeting system requirements would be considered during product improvement programs conducted after initial production and fielding. OWL inputs which have an impact on system design, therefore, are most effectively made prior to entry into this phase. Typical full scale development activities are described briefly with comments on their relationship to workload issues. These activities include:

- Full Scale Development Contract -- The full scale development contract is solicited on the basis of the technical data package developed during the validation phase. Full scale development prototypes are normally

typical in form and function of the expected production prototype. The contract also calls for evaluation and delivery of a complete suite of support equipment, to include test equipment, training devices, software, manuals, etc., as well as preparation of a technical data package for production. OWL related criteria should be one of the bases for evaluation of full scale development proposals.

- Technical and Operational Testing -- The complete system is tested and evaluated against criteria documented in the ROC or LR and developed in the TEMP. The Materiel Developer, and his contractor and technical tester (normally the US Army Test and Evaluation Command- TECOM) prepare and execute technical testing in accordance with the TEMP. The operational tester, either the Army Operational Test and Evaluation Agency (OTEA) ( for major systems) or a designated Training and Doctrine Command (TRADOC) school, address operational/user issues as specified in the TEMP. The resulting test reports are used to prepare technical and operational Independent Evaluations. Specialists develop tests, or make input into more general tests, in order to address OWL issues highlighted in the TEMP. OWL criteria which serve as a basis for accepting hardware or support equipment and software may be addressed in contractor testing for subsequent review by the government. OWL evaluation techniques are integrated as required into all testing.
- SMMP Update -- The SMMP is updated throughout the cycle to reflect analyses performed, questions and concerns addressed, new MANPRINT concerns that have been raised, as well as maintain an audit trail of all decisions and work that has been done in support of the SMMP.
- ILSP Update -- The updated ILSP is based on the ILSP prepared during the validation phase. The plan is expanded to address support of the system as it is introduced into the field. The ILSP is updated in concert with updates to the QQPRI, BOIP, incorporation into tables of organization and equipment (TOE), preparation of the Materiel Fielding Plan, and other ILS oriented actions. Test results and specific ILS studies are also used as a basis for the update. The results of OWL evaluations addressed during testing and other OWL studies provide OWL input.
- TEMP Update -- The TEMP is updated to support testing required during the production and deployment phase. Testing required to demonstrate that major deficiencies noted during technical and operational tests are corrected is described. Production validation tests and follow-on operational test and evaluation requirements are established. Requirements for first article and initial production tests are also established.
- AS Update -- The Acquisition Strategy is updated to emphasize production and deployment requirements. Critical OWL issues which remain to be addressed during the production and deployment phase may be presented as a MANPRINT consideration.
- Requirement Documents Revisions -- Revisions to the requirements document developed during the Demonstration and Validation Phase

(ROC, LR, TDR) must be considered to support production and deployment. Technical and operational characteristics may require revisions for a number of reasons including changes to the established threat. Any changes to the established requirement must be approved by both AMC and TRADOC and, in conjunction with the MADP, DA.

- Decision Coordinating Paper -- The DCP is prepared to support the production and deployment decision. It summarizes the results of full scale development and document recommendations for production and deployment. It includes a full description of the commitments the Army is making in proceeding with production, to include budget requirements and future support requirements. The revised Acquisition Strategy, with its required MANPRINT and human factors sections, is an annex to the DCP.

Typically, the same type of program management method is continued from that used in the Demonstration and Validation Phase. Development programs may be managed by a program or project manager, or by an acquisition management team appointed by the developing agency. TRADOC management is also normally continued with a TSM supported by combat development and training development elements. Programs which are project managed normally continue with that form of management, at least until the system is successfully fielded.

2.3.2.5 Production and Deployment (AR 70-1, Pam 70-2 )

During production and deployment operational quantities of the system and required support equipment is procured, personnel and operational units are trained, and the logistic support system is implemented to support the system in the field. If directed at the Milestone III decision point, Low Rate Initial Production may be implemented to address additional testing, production engineering or production base issues.

Follow-on Operational Test and Evaluation (FOTE) may be conducted during the production and deployment phase, if required, to address a spectrum of issues, including those with manpower and training impacts. FOTE has the potential to serve as relatively well controlled forum for developing OWL data upon which to base product improvement or new equipment requirement issues.

### 2.3.3 The Army Streamlined Acquisition Process ( AR 70-1 )

#### 2.3.3.1 Overview

The Army Streamlined Acquisition Process (ASAP) compresses the standard acquisition cycle from over eleven years to seven years or less. The objective of the streamlined process is to achieve operational capability within the minimum practical amount of time, for low risk development programs. Programs which need more detailed and deliberate development processes, generally characterized as higher risk development programs, may still follow all or portions of the "traditional" acquisition process.

The streamlined process is characterized by four distinct phases as seen in Figure 2.3.3-1. They are 1) Requirements and Technical Base Activities, 2) Proof of Principle, 3) Development-Production Prove Out, and 4) Production and Deployment. Proof of Principle is followed by a go/no-go decision (Milestone I/II) to proceed into the development/prove out phase. The focus of the streamlined process is in the development/prove out phase. Activities typical of traditional full-scale development and early production/deployment are conducted as expeditiously as practical. Development/prove out is followed by a Milestone III decision point in order to provide approval to enter full production and deployment. The objective of the streamlined process is to achieve a Milestone III decision in fours years or less from demonstration of proof of principle. Overlaid on the streamlined acquisition procedure are provisions for preplanned product improvements (P3I) throughout the life of the system. New or improved technology is "inserted" at appropriate points throughout the life cycle as the threat or the technology changes. These insertion points may be during the development/prove out stage, as well as during the production and deployment phase or later in the cycle.

Documentation prepared during the conduct of programs under the streamlined acquisition process is similar to that prepared under the traditional process. OWL considerations for analysis and the development of design approaches and documentation are identical in comparison to those conducted during the traditional process. Successive iterations of documentation, as the system proceeds through the stages of development under the traditional process, are eliminated. OWL considerations for the development of specific documentation under the streamlined process will not be repeated here. Figure 2.3.3-1 illustrates how OWL considerations should enter the ASAP; these are identical to

# OWL IN THE STREAMLINED LIFE CYCLE

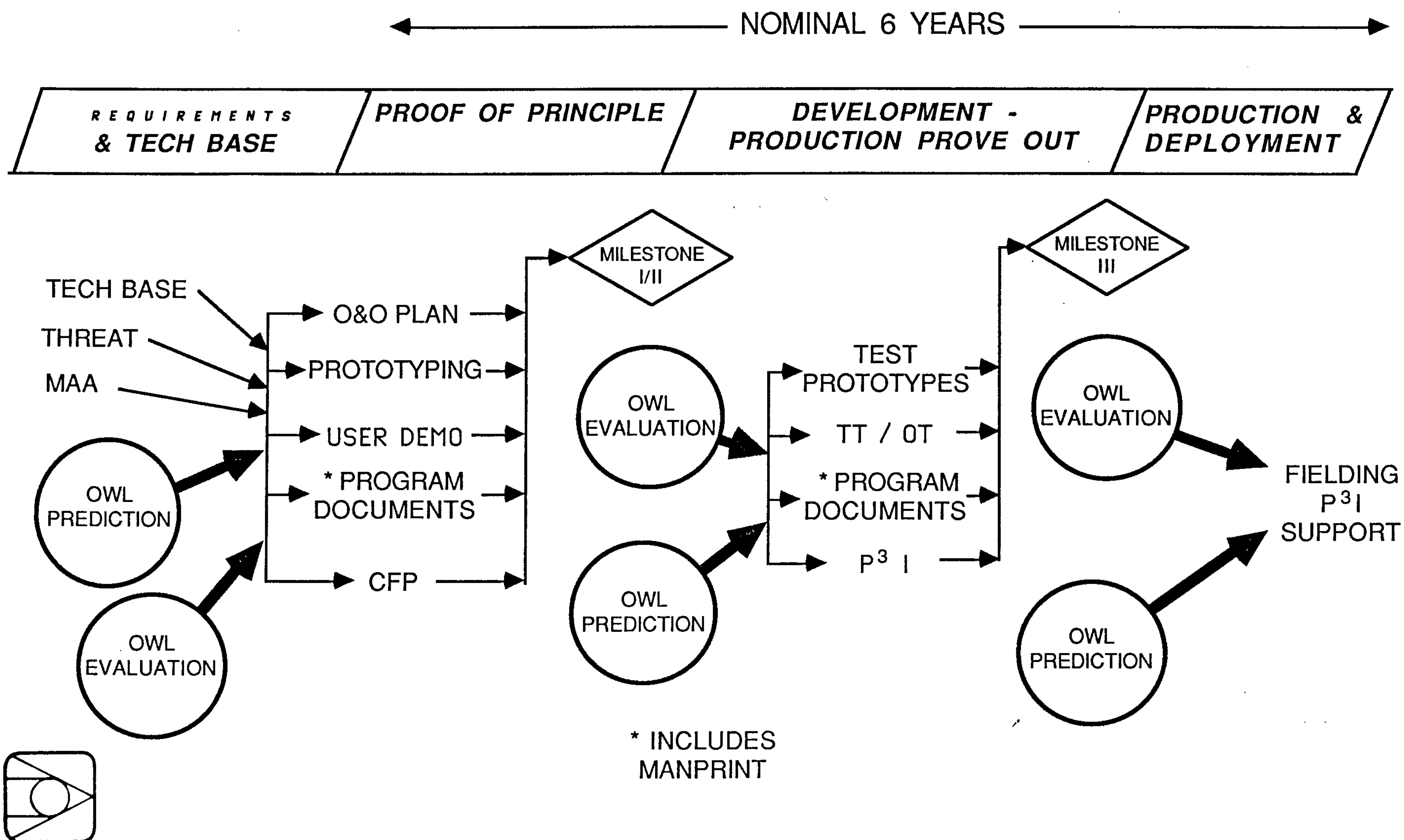


Figure 2.3.3-1 OWL Considerations in the ASAP

those in the traditional process. It is important to emphasize that as the process is compressed, so too are the opportunities for and impacts of OWL consideration. The most important phase of development under the Streamlined Acquisition Process in considering OWL inputs is Proof of Principle. Incorporation of OWL enhancements will be much more cost effective and efficient during and immediately after the proof of principle phase, in comparison to later in the Streamlined Acquisition Process. A brief description of each phase under the streamlined process, with emphases on OWL considerations, is presented below.

#### 2.3.3.2 Discussion of ASAP Phases

The first phase is the Requirements Definition/Technical Base Activities. Activities conducted during this phase are similar to the program initiation activities under the traditional process. They ultimately result in development of a JMSNS, or, as a minimum, an O&O Plan, and result in approval to proceed into the proof of principle phase. Basic program management documents such as the Acquisition Strategy, Acquisition Plan, SMMP and Test and Evaluation Master Plan may also be prepared during this phase. OWL considerations may drive requirements, as well as the accomplishment of technical base activities, such as research programs focused on OWL issues. OWL predictions, and the results of OWL evaluations of fielded systems which may address similar mission requirements, will impact the TEMP, SMMP, O&O Plan, and AS.

The ASAP calls for establishing a Technology Integration Steering Committee (TISC), with the objective of comparing technological opportunities with emerging requirements (AR 70-1, Paragraph 7-2c(2)). OWL considerations need to be considered by the TISC. TISC activities ultimately develop solutions which are suitable for consideration in hardware under proof of principle. Additionally, "Star" Reviews provide visibility and focus at the general officer level at the start of proof of principle. OWL considerations, based on related technical base activities, are issues for consideration by the TISC and during Star Review.

The second phase is Proof of Principle. Proof of principle consolidates activities conducted during concept exploration and demonstration/validation under the traditional process. The phase permits the conduct of user demonstrations and experimentation employing brassboard or surrogate systems in order to prove out the technical approach and operational concept. Proof of principle results in a "go/no-go" decision to proceed into

the development/prove out phase. Documentation supporting that decision (Milestone I/II) includes the CFP, TEMP, ILSP, and AS. MANPRINT and ILS issues are addressed on the basis of troop demonstrations and experimentation (AR 70-1, Paragraph 7-2f(3)).

Development of OWL requirements, and conduct of studies and analyses related to establishing OWL impacts, must receive strong emphasis during proof of principle. OWL evaluations of surrogate systems and brassboard prototypes serve as the basis for developing OWL requirements as a system enters the development/prove out phase. OWL predictions, based on systems currently in the field, will also make an important contribution to understanding OWL impacts. As with the early phases of the traditional MAP, OWL considerations will have their most cost effective impacts during proof of principle. Likewise, design features oriented to enhancing OWL characteristics must be identified during this phase. There will be little opportunity for modifying designs in order to enhance OWL characteristics during the development and prove out phase, except under the provision for preplanned product improvements (P3I).

The third phase is the Development/Production Prove Out phase. The development/production prove out phase encompasses activities which are similar to full-scale development under the traditional process. System characteristics are demonstrated using hard tool prototypes during technical and operational testing. Particular emphasis is placed on ILS, MANPRINT (AR 70-1, Paragraph 7-2g), and producibility engineering and planning. Documentation, and OWL considerations to be made during the preparation of that documentation, is similar to that required for full-scale development under the traditional process. OWL predictions and the results of OWL evaluations are sources of OWL data used in preparing that documentation. OWL evaluation methodology is employed during testing in order to demonstrate that prototypes meet required OWL characteristics.

Throughout this phase, requirements for P3I technology insertions are considered. Product improvements may be made during finalization of development/production prove out designs, or may be delayed until further into the production/deployment phase. OWL enhancements are more likely to be incorporated in a system which has entered the production/deployment or the development/prove out phases as P3Is. Based on a Milestone III review successful conduct of the development/production prove out phase results in both type classifying equipment as standard, and entering the production/deployment phase.

The final phase is the Production/Deployment Phase. The production/deployment phase includes low rate initial production (LRIP), first article testing (FAT), new equipment training, and initial fielding activities. Full rate production is achieved as initial fielding is completed and production models are demonstrated to achieve required capabilities. Documentation required under the streamlined process is similar to that required for the production/deployment phase. Generally, schedules for production/deployment under the streamlined process are compressed to one and a half to two years. OWL evaluation methodology may be used to demonstrate that production prototypes meet required OWL characteristics. OWL evaluations of fielded hardware may result in development of requirements for product improvement as production/deployment is completed. These requirements normally would be incorporated as a part of the overall P3I program for the system.

### 2.3.4 Adoption of Non-Developmental Items (NDI)

NDI is a candidate for fulfilling any material need. NDI include commercially available items, as well as items adopted by other services or friendly foreign nations. NDIs are considered in conjunction with market investigations accomplished early in the development cycle. If pursuing an NDI appears to be an acquisition alternative, a program to procure, test, and adopt the item is developed. There are two general categories of NDI (AR 70-1, Paragraph 7-3d):

- Category A -- Off the shelf items which need no further development or modification in order to achieve the required operational capability. These items would be expected to be used in a military environment under the same conditions for which they were intended in commercial environment.
- Category B -- Off the shelf items requiring modification to hardware designs or software in order to operate in the military environment. These modifications are typically required to ruggedize the item or enhance system survivability.

Acquisition Strategies for further development and fielding of NDI consider modifications needed and the requirements to demonstrate and prove the suitability of the equipment for military use. Adoption of an NDI does not eliminate the need to examine essential characteristics to include MANPRINT, systems safety, and logistic support concepts.

Conduct of NDI procurement programs are tailored to the requirement and the availability of suitable commercial or foreign equipment. NDI items which require considerable ruggedization with other modifications may drive establishing a program with features and requirements similar to a hardware development program. Sufficient testing must be conducted to prove operational, maintenance, and support characteristics. The features of the program are developed on the basis of the market analysis conducted prior to Milestone I.

ILS and MANPRINT issues vary from procurement to procurement. They are driven by the requirement and the characteristics of the commercial item and the Army's needs. The range of solutions varies from full acceptance of the commercial item, as taken "from the shelf" with a full commitment to future contractor maintenance and training support, to incorporation of the items into the Army training and logistic support system, and all combinations in between. All acceptable commercially available data is procured and utilized for system support.

The NDI program is tailored, based on the item characteristics and support available, to insure all requirements are met. For programs which need hardware modifications and/or development of training and support capabilities, the AS may be very similar to ASAP of a full system. The AS must address MANPRINT and ILS issues and resolutions must survive the MADP before adoption of an NDI.

### 2.3.5 Product Improvements (AR 70-1, AR 70-15, Pam 70-2)

Product improvement is a preferred method for responding to materiel requirements. They may range from modifications to a fielded item as a result of a Product Improvement Program (PIP) to planned evolutionary changes to a system in development (P3I). A PIP is distinguished from a P3I in that a PIP applies to systems which are already fielded and are no longer in production. Product improvements are an appropriate method of responding to workload deficiencies which are revealed late in the development cycle or in fielded systems. PIPs and P3Is are prioritized and integrated into the overall Army RDA program in the LRRDAP (see paragraph 2.3.2.2).

Product improvements may be applied to systems for a variety of reasons. For a PIP, these include: requirements to enhance human factors, safety or other MANPRINT

related system characteristics; improve system technical characteristics and operational effectiveness.as well as expand weapon system effective life. Preplanned Product Improvements (P3I) are required to be addressed in the requirements document for all developmental systems. They may be pursued to: reduce development time; reduce development risks; permit a timely response to changing threats; as well as respond to emerging technological opportunities. P3Is are also appropriate during system development to incorporate enhancements to: system performance characteristics and operational effectiveness; safety; human factors; and other MANPRINT requirements.

PIPs may be initiated by the materiel developer, the combat developer or field elements. The combat developer validates the need which precipitates the product improvement requirement. A Product Improvement Proposal is prepared and coordinated by the materiel developer. The Product Improvement Proposal fully documents the need for improvement and plans for development and application of the modifications. It includes an acquisition strategy and plans for developer and user testing to demonstrate the efficacy of the modifications. Detailed PIP procedures are established in AR 70-15. The PIP ultimately produces a DA Modification Work Order (DAMWO), Depot Maintenance Work Request (DMWR) or other approach to applying the modification and documenting it in the system technical data package.

P3I encourages an evolutionary approach to system design. That evolution is described in the acquisition strategy for the P3I program which are pursued in three phases:

- Phase I establishes how the system needs to evolve throughout the life cycle in order to respond to future operational requirements and technological opportunities.
- Phase II incorporates the results of Phase I into the basic system design.
- Phase III applies the modifications as block (i.e., several system changes) or individual changes.

Systems which have entered production and fielding must also make provision for the modification of systems already in the field.

## 2.4 OWL Issues in the Acquisition Process

### 2.4.1 How OWL Issues are Currently Addressed

One of the main objectives of the document review was to determine if and how operator workload issues (either physical or mental) were currently addressed as part of the Army MAP. Not surprisingly, there is not much specific discussion or guidance given in the regulations. There are more citations when the review is expanded to include mention and guidance concerning areas related to "workload issues" (e.g., human factors engineering, manpower, personnel, or other topic or term that considers soldiers as well as hardware). However, the connection and implications regarding OWL is more tenuous. This section addresses the specific references to workload that were found in the documents reviewed. The manner in which related topics are addressed in documents is also discussed in a more general context of OWL.

Documents from DoD, DA and subordinate organizations were identified. Within each document, other documents are listed (as required publications) which are necessary for complete understanding and implementation. In addition, there are also reference or related publications which may contain useful information but are not essential for complete understanding. By comparing the lists of required and related publications, a "document tree" may be established as graphically displayed in Figure 2.4.1-1. In this "tree", AR 70-1 may be seen to be the key Army acquisition document. It is associated with other ARs describing aspects of the acquisition process and with DoD high level guidance for military system acquisition. AR 70-1 also requires more technically oriented ARs such as AR 602-1 and 602-2. With regard to OWL, the most explicit reference to operator workload in Army-wide documents is contained in MIL-H-46855 (cf., Section 2.4.1.2). There are specific Data Item Descriptions associated with this military specification and, in turn, this military specification is directly related to the Human Factors Engineering AR. This indicates that these "workload"-related DIDs are only referenced via the HFE AR 602-1. The relationship shown in this document tree could be kept in mind during the more thorough discussion of the ARs, DoD guidance, and other related documents which follows.

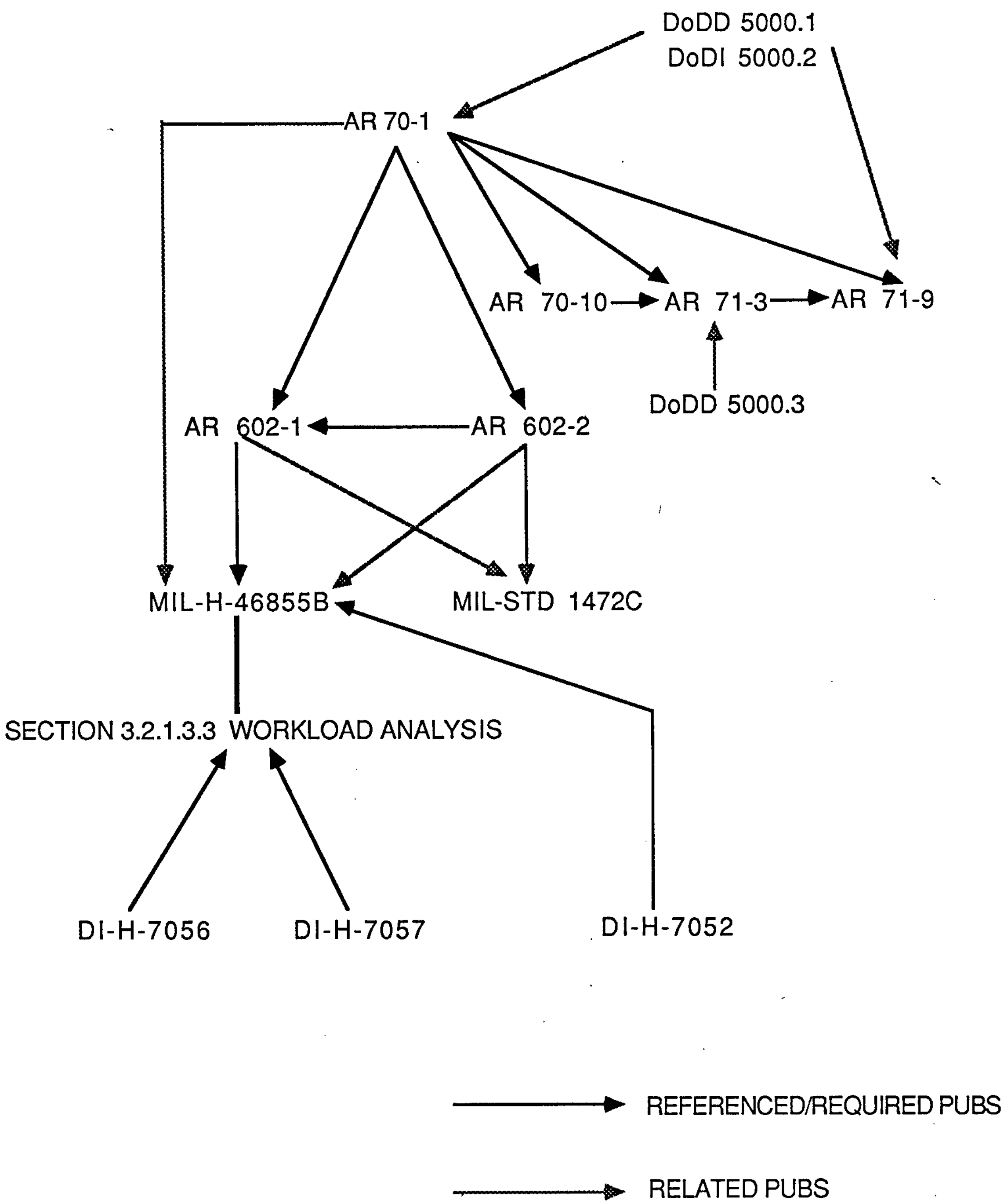


Figure 2.4.1-1. OWL- Related Relationship Between Primary Documents.

#### 2.4.1.1 Army Regulations

A review of Army Regulations (ARs) was undertaken to identify those that govern system acquisition and any requirements for operator workload considerations as described earlier. The key documents identified are listed in Table 2.4.1-1. Of these, the first two (AR 70-1, -10) are in the Research and Development series. The next two (AR 71-3, -9) are in the Force Development series. ARs 602-1 and -2 are in the Soldier-Materiel Systems series. These regulations represent basic policy, guidance, and required formats in these three areas.

Table 2.4.1-1 Key Army Regulations

| AR | Title | Effective Date |
|---|---|---|
| AR 70-1 | System Acquisition Policy and Procedures. | 1 Dec 86. |
| AR 70-10 | Test and Evaluation | 30 Apr 86. |
| AR 71-3 | User Testing | 1 Mar 86. |
| AR 71-9 | Materiel Objectives and Requirements | 20 Mar 87. |
| AR 602-1 | Human Factors Engineering Program | 15 Feb 83. |
| AR 602-2 | Manpower and Personnel Integration (MANPRINT) in Materiel Acquisition Process | 18 May 87. |

A brief summary of these ARs indicates the major content and intention of each:

- AR 70-1 covers basic policies and procedures for Army system acquisition and "emphasizes front-end planning and tailoring of the materiel acquisition process..." (p. 3). The ASAP is introduced and its policies and procedures described.
- AR 70-10 covers basic policies and procedures for test and evaluation and provides information concerning test and evaluation for use at decision reviews.
- AR 71-3 covers policies and assigns responsibilities for user test and evaluation and continuous comprehensive evaluation (C2E) in the MAP.

- AR 71-9 covers policies and procedures and assigns responsibilities for preparing requirements documents for materiel and gives guidance for the combat development process within the MAP.
- AR 602-1 integrates human factors engineering throughout the MAP.
- AR 602-2 covers policies and procedures for the MANPRINT Program and establishes the requirement for the System MANPRINT Management Plan (SMMP). MANPRINT is an umbrella concept that encompasses HFE, manpower, personnel, training, health hazard assessment, and system safety.

These six documents do not specifically address OWL. Army Regulation 70-1 does, however, establish the policies, procedures and requirements for all applicable Army system acquisition programs. It calls out both AR 602-1 and 602-2, and specifies MANPRINT inputs into the different phases of the traditional Life Cycle System Management Model (LCSMM). Additionally, it specifies that MANPRINT considerations must be included in tailored acquisition programs (e.g., ASAP and NDI) and materiel improvements [i.e., Engineering Change Proposals (ECP), Product Improvement Proposals (PIP), or Preplanned Product Improvements (P3I)]. Specifically, it provides that "No acquisition . . . is exempt from minimal essential test and evaluation necessary to verify the MANPRINT . . . characteristics of a system . . . unless previous test and performance data or market analysis (information) is adequate for verifying operational effectiveness and suitability of the system" (p. 27). Sections 3-8 and 3-9 of AR 602-2 also define MANPRINT requirements for NDI and product improvements. In fact, MANPRINT concerns alone can provide the justification for a product improvement. MANPRINT considerations are clearly related to OWL.

While not specific to OWL, higher level documentation calls out HFE requirements in all phases of the acquisition process. AR 602-1 specifies HFE requirements throughout the materiel life cycle and stipulates that the HFE program shall be performed in accordance with MIL-H-46855B, thereby indirectly establishing the requirement that OWL issues need be addressed. Also, program objectives such as to ". . . Insure, through basic and applied studies and research in HFE . . . that equipment designs and operational concepts are compatible with the capabilities and limitations of operators and maintenance personnel" (p. 1-4) additionally point toward addressing workload issues.

In concert with AR 602-1 is the Army's new regulation for the implementation of its MANPRINT concept, AR 602-2. As it may be recalled, MANPRINT is an umbrella concept that encompasses HFE, manpower, personnel, training, health hazard assessment,

and system safety. As such, it (AR 602-2) assumes the responsibility for coordinating the requirements of its constituent domains. Thus, MANPRINT policy provides that HFE Analysis will be prepared in accordance with AR 602-1 on all Army major, designated acquisition, and in-process review (IPR) programs. Also, like AR 602-1, AR 602-2 addresses the concept of workload without specifically using the term [e.g., " . . . Analyses of the work environment also includes consideration of the physical and cognitive demands on personnel . . ." (p. 3), and " . . . Ensure through studies and analyses and basic and applied research (human factors engineering, . . . ) that equipment designs and operational concepts are compatible with the limits of operators and maintainers defined in the target audience descriptions . . . " (p. 3-4)]. Thus, specification of MANPRINT analysis requirements is equivalent to specifying HFE and OWL analysis requirements within the appropriate problem domain. This is important because higher level documentation, such as AR 70-1 tends to address issues and requirements more generically as MANPRINT issues and requirements. This leaves the relevant lower level documents to spell these out the details for the six application areas of MANPRINT.

This review altogether lead to the conclusion that attention to OWL concerns is currently required for all Army materiel acquisition programs. In part, this conclusion is not immediately obvious because at upper levels of acquisition process requirements, the OWL issues are subsumed under the more general requirements for MANPRINT/HFE. Also coupled with this is the fact that until recently, with the advent of programs like MANPRINT, HFE issues have not always received their proper attention. This may be especially true for operator workload analysis which have not been as well developed as other more traditional analyses of HFE.

#### 2.4.1.2 Military Specification MIL-H-46855B and Associated Data Item Descriptions

The purpose of Military Specification MIL-H-46855B is to establish and define requirements for applying human engineering to the development and acquisition of military systems, equipment, and facilities. The human engineering effort consists of analysis, design and development, and test and evaluation. An outline of the detailed requirements are given in Table 2.4.1-2.

Table 2.4.1-2 Outline of MIL-H-46855B Requirements

- 3. REQUIREMENTS
  - 3.1 General Requirements
    - 3.1.1a Analysis
    - 3.1.1b Design and Development
    - 3.1.1c Test and Evaluation
    - 3.1.2 Human Engineering Program Planning
    - 3.1.3 Nonduplication
  - 3.2 Detail Requirements
    - 3.2.1 Analysis
      - 3.2.1.1 Defining and Allocating System Functions
        - 3.2.1.1.1 Information Flow and Processing Analysis
        - 3.2.1.1.2 Estimates of Potential Operator/Maintainer Processing Capabilities
        - 3.2.1.1.3 Allocation of Functions
      - 3.2.1.2 Equipment Selection
      - 3.2.1.3 Analysis of Tasks
        - 3.2.1.3.1 Gross Analysis of Tasks
        - 3.2.1.3.2 Analysis of Critical Tasks
        - 3.2.1.3.3 Workload Analysis
        - 3.2.1.3.4 Concurrence and Availability
      - 3.2.1.4 Preliminary System and Subsystem Design
    - 3.2.2 Human Engineering in Equipment Detail Design
      - 3.2.2.1 Studies, Experiments and Laboratory Tests
        - 3.2.2.1.1 Mockups and Models
        - 3.2.2.1.2 Dynamic Simulation
      - 3.2.2.2 Equipment Detail Design Drawings
      - 3.2.2.3 Work Environment, Crew Stations and Facilities Design
      - 3.2.2.4 Human Engineering in Performance and Design Specifications
      - 3.2.2.5 Equipment Procedure Development
    - 3.2.3 Human Engineering in Test and Evaluation
      - 3.2.3.1 Planning
      - 3.2.3.2 Implementation
      - 3.2.3.3 Failure Analysis
    - 3.2.4 Cognizance and Coordination

The analysis section deals primarily with task analysis, function allocation, and estimates of potential operator/maintainer processing capabilities. Specifically, it provides:

> "3.2.1.3.3 Workload Analysis - Individual and crew workload analysis shall be performed and compared with performance criteria."

However, no further information is given as to how to perform such an analysis nor what performance criteria should be used. This specific reference for OWL analysis consequently comes under the domain of Human Factors Engineering (HFE). This military specification contains in its appendix an application matrix that gives guidelines as to what sections of the specification should be applied during what phases of the life cycle as well as what modifications should be made depending on the life cycle phase. The MIL-H-46855B appendix shows that specific workload analysis provision is in effect in all phases of the life cycle.

Data item description (DID) describes data and prescribes preparation instructions for the data for the analyses called out by MIL-H-46855. The series of DIDs on human factors engineering call for a wide range of information -- the DIDs are listed in Table 2.4.1-3. The specific DIDs that contain the requirements for implementation of this section are DI-H-7056, Human Engineering Design Approach Document - Operator (HEDAD-O), and DI-H-7057, Human Engineering Design Approach Document - Maintainer. DI-H-7052, Human Engineering Dynamic Simulation Plan, while not referencing Section 3.2.1.3.3, does contain the specific provision for the use of dynamic simulation for workload analysis. Of particular interest is DI-H-7056 because of its specific application to operators. Basically, the operator-equipment interfaces and the task analyses results are to be presented in the HEDAD-O.

### 2.4.1.3 Aeronautical Design Standard-30

The Aeronautical Design Standard for Human Engineering Requirements for Measurement of Operator Workload (ADS-30) was the only Army document found that dealt specifically with OWL. The proponent is the U.S. Army Aviation Systems Command, St. Louis, MO. ADS-30 "establishes the requirement for a comprehensive, broadly-based workload assessment" to identify workload "chokepoints" in materiel systems (i.e., Army aviation systems). This standard provides for the workload assessment to be carried out throughout the design and development portions of the

Table 2.4.1-3 Human Factors Engineering Data Item Descriptions

| Number | Title |
|---|---|
| DI-H-7051 | Human Engineering Program Plan |
| DI-H-7052 | Human Engineering Dynamic Simulation Plan |
| DI-H-7053 | Human Engineering Test Plan |
| DI-H-7054 | Human Engineering System Analysis Report |
| DI-H-7055 | Critical Task Analysis Report |
| DI-H-7056 | Human Engineering Design Approach Document--Operator |
| DI-H-7057 | Human Engineering Design Approach Document--Maintainer |
| DI-H-7058 | Human Engineering Test Report |
| DI-H-7059 | Human Engineering Progress Report |

acquisition process. Types of OWL techniques are discussed and management methods for assessment by contractors are discussed.

#### 2.4.1.4 Department of Defense Documents

Three Department of Defense (DoD) level documents pertaining to system acquisition were reviewed for guidance regarding OWL. (These are listed in Table 2.4.1-4.) DoD Directive (DoDD) 5000.1, the first of these, presents DoD acquisition policy for major systems or major modifications to existing systems. Broad guidance for technical issues is included in the list of acquisition management principles and objectives. The most applicable principle to OWL issues is that improved readiness and sustainability are primary objectives, with operational suitability of equal importance to operational effectiveness. Operational effectiveness is the overall degree of mission accomplishment of the system.

Operational suitability is the degree to which the system can be placed satisfactorily in field use, with consideration given to availability, compatibility, transportability, interoperability, reliability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistic supportability and training requirements. Operational suitability includes the ability of the soldier to operate, maintain and support the system, which would include OWL.

Table 2.4.1-4 Department of Defense Documents

| Document | | Subject | Date |
|---|---|---|---|
| DoD Directive | 5000.1 | Major Systems Acquisitions. | 12 Mar 86. |
| DoD Instruction | 5000.2 | Major System Acquisition Procedures | 12 Mar 86. |
| DoD Directive | 5000.3 | Test and Evaluation | 12 Mar 86. |

DoD Instruction (DoDI) 5000.2 describes the procedures to implement DoDD 5000.1. Workload issues are never specifically addressed, but might become topic areas included in a program review or in the program documents used in support of DoD level decisions. DoDD 5000.3 provides policy and guidance for test and evaluation in DoD and provides guidance for the TEMP. Again, specific issues are not addressed in this directive, although "use of properly validated analysis, modeling and simulation is strongly encouraged, especially during early development phases..." (p. 3). An important aspect of testing and evaluation is addressing critical issues that have been identified or may arise throughout the MAP. The DoD Directives (5000.1-5000.3) do not address specific OWL but provide high level policy that operational suitability is important and test and evaluation should address important issues.

#### 2.4.1.5 Other Sources

Table 2.4.1-5 lists several further Army sources which that address OWL. The MIL-STD 1472C, the first of these, is the basic military standard for human engineering design criteria. The general requirements for equipment design include the principle "Design shall be such that operator workload, accuracy, time constraint, mental processing and communication requirements do not exceed operator capabilities" (p. 13). Similarly, software is to be designed to minimize task complexity and memorization. Operator response times will be with operational task limits (p. 242). The term "workload" appears in one other place; on p. 63, it is stated that the "distribution of work load" should be such that none of the operator limbs are overburdened. This is workload in the functional allocation sense. Interestingly, "workload" does not appear in the index. MIL-STD-1472C is a basic document where designers might look for information, but does not provide any information or suggestions specifically addressing OWL (with the few exceptions noted above).

Two sources were provided to us by individuals at TECOM. The TECOM Pamphlet 602-1 (Vol. 1), in particular, describes how to design subjective opinion tests and was identified by those individuals as "what was used to assess workload in technical tests." The second source was the Test Operating Procedure (TOP) 1-2-610 which provides detailed design criteria against which to test equipment. One of the procedures included is a Workload Assessment (p. 131) which suggests a time-line analysis and supplementing these observations with subjective questions. A Workload Assessment form is included with headings such as critical task, time required, additional tasks conducted simultaneously, effects of time delays in task completion, overload problems and underload problems. This is addressing "workload" in the context of sharing or consolidating the tasks to be accomplished.

Table 2.4.1-5 Other Army OWL Sources

| Document | Title | Date |
|---|---|---|
| MIL-STD-1472C | | |
| | Human Engineering Design Criteria for Military Systems, Equipment and Facilities | 2 May 81 |
| ADS-30 | Human Engineering Requirements for Measurements of Operator Workload | 17 Nov 86 |
| TECOM Pam 602-1 | | |
| (Vol I) | Questionnaire and Interview Design (Subjective Testing Techniques) | 25 Jul 75 |
| TOP 1-2-610 | Human Factors Engineering Data Guide for Evaluation (HEDGE) | 20 Nov 83 |

Several documents originally identified as relevant were unavailable for the present review because they are under revision or out of stock at the document distribution center. The documents include:

- MIL-HDBK-759 "Human Factors Engineering Design for Army Materiel"
- AR 10-41 "Organization and Functions, U.S. Army Training and Doctrine Command"
- AR 15-14 "Systems Acquisition Review Council Procedures
- MIL-STD-1388-1/2 "Logistic Support Analysis"/"Logistic Support Analysis Record"

Efforts to obtain and review these particular documents as well as identify, obtain and review other relevant documents to enhance our understanding of OWL requirements will continue. It is , however, believed that the present review has essentially revealed the status of OWL in the Army MAP.

### 2.4.2 Terminology

The term "workload" carries a multitude of meanings within the military community. For example, HARDMAN-type manpower, personnel and training (MPT) analyses specify workload and workload analysis for system operators and maintainers. Within this context, however, workload is defined as the number, frequency and durations of activity-based tasks, performed by a specific number of personnel of particular MOS's, skill levels and paygrades. The output of workload analyses are numbers and grade qualifications of personnel necessary to operate and/or maintain a system. This performance/manhour based interpretation is much more restricted than that which is taken here or that is necessary to fully address OWL issues. Within other contexts, it is clear that workload does not refer to cognitive/physical underload or overload, but rather to task-based manning considerations. It seems, then, that care must be taken to clearly discuss exactly what is being discussed when using terms like "workload" and "workload analysis". Certainly, manpower considerations are closely tied to potential "cognitive overload" (see section 2.4.3), but they are different and should be clearly differentiated. Care must also be taken, as intended here, when addressing a military audience to insure that the proper framework for discussing perceptual, cognitive, psychomotor workload, is established up front.

### 2.4.3 MANPRINT

The Army Manpower and Personnel Integration (MANPRINT) initiative focuses on the soldier-in-the-loop and front-end analysis in the acquisition process. As noted earlier, MANPRINT seeks to integrate six areas that are concerned with the soldier into the materiel acquisition process so that soldier needs and abilities are considered early in the process. The six areas, called domains, are Manpower, Personnel, Training, Human Engineering, Health Hazards Assessment, and System Safety.

#### 2.4.3.1 Interrelationships between OWL and the Domains

Manpower, personnel and training (MPT) are critical areas in the Army MAP. Manpower is concerned with force structure and deals with how many people and of what Military Occupational Speciality (MOS) are needed to operate, maintain, and support materiel. These are sometimes referred to as the "spaces." Personnel issues deal with the

kind of people needed to operate, maintain, and support materiel. People in this context are recognized as possessing different levels of intelligence and skill, as well as different personality attributes. Personnel issues are sometimes referred to as the "faces", implying the individual characteristics of the soldier. Training, of course, is the instruction of the soldier in specific skills and procedures needed to perform necessary tasks. Training is done in schools and in units and many methodologies are used. Each of these areas must be addressed in the development of Army requirements and are not synonymous with OWL. However, there are interrelationships between OWL and MPT that should be kept in mind as this effort proceeds.

One relationship between manpower and OWL is the term "workload" (as discussed in Section 2.4.2). For many tasks, it is not inappropriate to conclude that if there is too much for one person to do in a certain amount of time to specific criteria levels, then having two people do the job will take care of the problem. However, this relatively simple addition of more people (assuming that the additional people with the needed abilities are available) will not solve every problem. The process of perceiving and processing must ultimately rest on single operators in many circumstances. Adding another person in this case would not help.

The distinction between between manpower and OWL concerns may be made by questioning (1) whether the task(s) that are creating the "workload" are of the kind that can solved by just adding another person or (2) is the nature of the task such that it must be done by an individual and it requires too much in too short a time period.

Personnel issues are concerned with the individual characteristics of the soldiers. The interrelationship between OWL and personnel issues involve such areas as the trade offs between intelligence and "quality" as identified by the ASVAB (i.e., mental categories I-IV) and the degree of soldier perceptual, cognitive, or psychomotor loading. Trade offs may need to be identified depending on the types of soldiers available because of this interaction of personnel characteristics and system design.

Training is another area with which OWL is interrelated. Increased training gives the soldier knowledge, skills, and practice in the required tasks. Additional training may be and is frequently treated as <u>the</u> solution to overcome inadequate performance. However, training often may not be effective in reducing workload, or a cost effective way of and enhancing performance (Hart, 1986). In order to adequately control the more cognitive

workload, there may need to be trade offs made between training and the quality of soldier chosen as the operator. Another alternative is to affect the hardware design as part of HFE.

Human Factors Engineering (HFE) is concerned with the engineering design of equipment and the soldier-machine interface so that system performance (including the human element) is maximized. OWL issues are interrelated with HFE in the design of the equipment, specifically the soldier-machine interface design. If an interface has been designed well, the ease with which the operator can perceive information or perform motor tasks may be optimal, thereby reducing workload. An unthoughtful and poorly designed interface may be the major factor in creating a workload intensive task. Human factors engineering solutions should certainly be among the first pursued when overload problems are identified.

Health hazard assessment (HHA) is concerned with any condition inherent to the use of equipment that may cause degradation of job performance, chronic disability or death. Health hazards include toxic substances, vibration, noise, temperature extremes and psychological stressors. Although this last area is not universally considered a health hazard, psychological stressors, such as confined spaces, isolation, sleep deprivation, and sensory/cognitive overload, may cause serious degradation or chronic disability in job performance. There is currently no overall Army program addressing these psychological stressors from a HHA perspective. However, health hazard assessors try to identify potential problems early in the acquisition process and raise a flag that this issue must be considered as the MAP continues (LTC B. Leibrecht, USAARL, personal communication, 30 April 1987). OWL should be an issue from the HHA perspective in the acquisition process.

System safety (SS) is concerned with identifying and eliminating or reducing the risks associated with system (particularly hardware) characteristics that may cause injury or death. The results of hardware failure (e.g., electrical shorts or restraint harnesses breaking) are of particular concern. OWL issues are related to the safety of the system only and to the extent these risks intrude and occupy the operator.

It can be concluded from the above discussions that operator workload is related to all six areas of MANPRINT. It is not clearly synonymous with, nor falls under the specific purview of, any particular domain. However, the interrelationships between OWL and the MANPRINT domains are important considerations in developing system

requirements and design. Considerations of these interrelationships will identify MPT, HFE, HHA or SS trade-offs that may be made in an effort to control OWL as system requirements and design are defined.

As specified by the Army in its training courses on MANPRINT, there are several tools to be employed by the six MANPRINT domains. Among these is workload analysis, which the Army indicates is to be used during all phases of the acquisition process to answer such questions as:

- Which design alternative is the best?
- What training will be required?
- Can operators perform all functions effectively?
- What design inadequacies exist that must be rectified?

These questions as well as others are raised during the various phases of the acquisition process as appropriate, and workload estimation and measurement techniques must be developed that can provide timely answers.

#### 2.4.3.2 System MANPRINT Management Plan

The System MANPRINT Management Plan (SMMP) is the "planning and management guide and an audit trail to identify tasks, analyses, trade-offs, and decisions that must be made to address MANPRINT issues during the materiel development and acquisition process" (AR 602-2, p. 12).

The SMMP is initiated very early in the acquisition process by the combat or training developer and requires consideration of concerns and questions that may affect soldier performance in Army equipment. This is an appropriate and logical place to include OWL concerns and has the important attribute of being initiated at the very outset of materiel requirements development. The SMMP is to be started prior to the program initiation, and most likely will be developed concurrently with the O & O Plan. Even at this point, OWL concerns can be raised and methods to answer questions and address concerns can be suggested.

The format for the SMMP is given in Appendix B of AR 602-2. The five major sections include:

- a summary of MANPRINT strategy

- a description of the proposed system, with the acquisition strategy, agencies involved and any existing guidance also described
- a description of the MANPRINT strategy including the objectives, data source availability, and planned MANPRINT analyses
- any issues or areas of concern which have been identified
- the tabs, which include list of data sources, MANPRINT milestone schedule, task description, questions to be resolved, and list of all organizations with which the SMMP must be coordinated.

Although the regulation requiring the SMMP is new (17 April 1987), some guidance is available through the SMMP Procedural Guide (1986). It is expected that as more experience is gained by those who prepare the SMMP, the SMMPs will increasingly address issues in the MANPRINT areas and provide a useful management plan to control factors such as OWL.

The SMMP has several sections which provide opportunities to address OWL concerns early and throughout the MAP. In particular, the Concerns section (paragraph 4) is the place to discuss any identified issues in the system development. These concerns are those that should be monitored throughout the MAP. Further, the Questions to be Resolved (Tab D) are the detailed questions that need to be answered to address the concerns identified in Paragraph 4. These questions should be detailed and specific. In some ways, development of the Tab D questions will lead to the analyses that need to be done in order to obtain sufficient information to answer the questions (these analyses are to be presented as part of Paragraph 3b as well as the identification of predecessor or reference systems and what kind of data is expected to be available for use). Tab A is also identified as the place to list all potential data sources in all the MANPRINT domains and should also include those relevant to OWL. A description of the tasks to be done in support of MANPRINT efforts are to be presented in Tab C. These descriptions include the rationale, resources needed, time to complete, and responsible agencies.

Clearly, if an awareness of and sensitivity to OWL issues can be developed by those preparing the SMMPs, then their format should provide the means to surface broad concerns about workload issues and well as the specific questions that need to be investigated in order to adequately address the stated concerns. The identification of predecessor system and data list will directly affect the types of OWL predictive and/or evaluative assessments that can be conducted. Similarly, it will affect the timeliness with which such assessment can be performed in the sense that well-documented data sources and known availability will facilitate its gathering and application.

Any key OWL issues or concerns should also be included in the summary (Paragraph 1) which presents an overview of MANPRINT. The summary will be the portion most often read by decision makers and will give visibility to the key issues. The status of key issues can be monitored and managed as the SMMP is continually updated with current information.

Another aspect of the SMMP that is of interest in the control of OWL is the role of the MANPRINT Joint Working Group (MJWG). Although the SMMP is the responsibility of the Combat Developer (i.e., TRADOC), it is to be developed in conjunction with the Materiel Developer (i.e., AMC). The MANPRINT Joint Working Group (MJWG) is the group of people that work together to create the SMMP and includes representatives from the Combat Developer, the Materiel Developer, and other organizations that are involved. The SMMP should consequently have inputs from all interested organizations and they can play a part in the lists of concerns, questions, and tasks to be accomplished.

### 2.4.4 Identified Army Projects

During the document review, other procedures and analyses that have been developed for the Army and that may be useful in this effort were identified. As we continue our investigations, existing procedures or information that can be used in workload analyses will be utilized to the fullest extent possible. Some of the identified sources and the potential use in OWL assessment are delineated in the following.

#### 2.4.4.1 Early Comparability Analysis (ECA)

The Early Comparability Analysis (ECA) Procedural Guide (1986) summarized that "the ECA methodology is based on a 'lessons learned' approach to the design of a conceptual system" (p. 1). For ECA, a predecessor (or reference) system is identified with which to compare the conceptual system. Relevant MOSs are identified, task lists for those MOSs are obtained (or derived if not available). Subject Matter Experts (SMEs) are also consulted to assign "difficulty" ratings to tasks using six task criteria: percent performing, task learning difficulty, task performance difficulty, frequency rate, decay rate, and time to train. Those tasks costly in MPT resources are identified and solutions are proposed to eliminate or reduce the cost of these "high drivers."

ECA uses a combination of several analytic techniques to identify MPT resource-intensive tasks (comparison, SMEs, task analysis) . As discussed previously, MPT issues are interrelated with OWL issues and their treatment in the context of an analysis already in place can yield OWL information very early in the MAP. This could enhance the development of OWL analyses as ECA is designed for use by combat developers as an in-house tool, therefore it is not intended to be a highly sophisticated tool for use only by technical experts. OWL estimations have been previously made based upon comparability (e.g., Shaffer et al., 1986), SME (Zachary, 1980), and task analysis (e.g., Stone et al., 1985).

#### 2.4.4.2 Hardware vs. Manpower (HARDMAN)

The HARDMAN Comparability Analysis is a "structured approach to the determination of the Manpower, Personnel and Training (MPT) requirements of a weapon system in the earliest phases of its development" (Mannle, Guptill, and Risser, 1985). HARDMAN is primarily an MPT analysis and sophisticated comparison methodology is used to derive estimates for MPT. It does produce task analyses with time-lines that could be used for certain OWL estimation methodologies (e.g., Stone et al., 1985). However, HARDMAN is a sophisticated tool -- currently only one company performs the analyses for the Army -- and it is expensive to do. Therefore, HARDMAN will, most likely, not be available for use on all systems and may not be expected to provide a broad basis for predictive analyses of OWL.

#### 2.4.4.3 Logistic Support Analysis (LSA)

The Logistic Support Analysis (LSA), as described by AR 700-127, is performed to identify existing or proposed support structure and requirements, as well as apply Integrated Logistics Support (ILS) and MANPRINT influence in system design and selection. LSA is required in all acquisition programs. As part of the LSA, certain tasks are required of both the combat and materiel developers. Such tasks as use studies (Task 201), comparative analyses (Task 203), and task analyses (Task 401) are required in accordance with MIL-STD-1388. The LSAR may be a useful source of data for maintainer workload estimation and evaluation. Further investigation is needed to determine what data would actually be available for use for assessments of OWL.

### 2.4.4.4 Human Resources and Test Evaluation System (HRTES)

The Human Resources and Test Evaluation System (HRTES) (Kaplan, Crooks, Sanders and Dechter, 1984) is a set of procedures designed to assist a test planner to evaluate operator and maintainer performance in an operational test of an Army system. The HRTES procedure takes the test planner through a series of steps from general system issues to the highly specific human performance issues. For example, a set of considerations would be to 1) define mission performance 2) define performance conditions such as weather, 3) identify system performance issues and criteria and then 4) identify human tasks and performance criteria for each task. Interspersed through this analysis is the reminder of the need for planning and for identifying the techniques for measuring each of the criteria. The HRTES procedures have potential utility for OWL assessment with regard to identifying and defining system characteristics for use in the selection of individual techniques.

### 2.4.4.5 MANPRINT Data Base

A MANPRINT data base is currently under development at the U.S. Army Materiel Readiness Support Activity. The main purpose of the data base is to organize MPT, HFE, HHA and SS data for use in comparative analyses. The data base will contain historical data organized by end item. The MPT portion will contain such items as RAM data, MOSs related to the end item, manhours and tasks. The HFE, HHA, and SS area will be addressed in more of a "lessons learned" approach, with any problems being identified and solutions (if any) given. The plan is to have the programming of the data base on line by 4th Quarter, FY 88. However, it may be 2 or 3 years before the loading of the data is complete and the data base is accessible to outside users.

A key problem in the data base development is the availability of operator data. So far only the maintainer is fully documented, primarily because generic functions/subtasks are more easily defined for maintainers. It is much more difficult to define generic functions/subtasks for operators (Mr. G. Tarber, USAMRSA, personnel communication, 8 May 1987).

As the data base is further developed and becomes accessible, it may provide a good source of data for workload and comparability analyses. Currently, however, operators are not addressed and there is not a firm plan on how to do so.

### 2.4.4.6 Summary

These procedures have been identified as potential sources of information or data for use in OWL assessments. The descriptions of the procedures and how they may be used for OWL assessment are only preliminary judgments. Additional methods and procedures as well as application potentials may be expected to evolve because of the increasing interest in programmatic effort (e.g., MANPRINT).

### 2.4.5 Conclusions and Recommendations

A number of conclusions can be drawn from the document review. Some of these conclusions will have an impact on the future tasks of the OWL project in directing how the guidance for OWL assessment are written (i.e., the handbooks). The major conclusions and recommendations are:

- In general, there is a void in Army documents on the topic of OWL.
- OWL assessment is required (via MIL-H-46855), but indirectly through the areas of HFE and MANPRINT.
- There do not seem to be any inconsistencies regarding OWL, primarily because there isn't much available.
- The intent to consider the soldier in materiel acquisition is clear in high level DoD Directives.
- Clear distinctions between types of workload must be made.
- Effort should be made to make use of existing projects as much as is appropriate.
- ASAP, NDI and product improvement strategies will make early attention to OWL even more critical.
- MANPRINT provides a framework on which to build and provides places to address OWL issues (e.g. the ROC and the SMMP).
- The MANPRINT portion of the ROC is an appropriate place to address soldier-in-the-loop requirements (e.g., OWL) for the new equipment.
- The SMMP would be a useful vehicle to focus attention on potential OWL problems and devise plans to address OWL throughout the MAP.

The review of the documents provided a useful means to understand the current Army requirements and how issues concerning operator workload are addressed. The lack of specific guidance was not really surprising -- there has been greater awareness in recent times because of the technological advances being included in Army materiel. The identified lack emphasizes the timeliness and importance of the current OWL project effort.

# 3. ASSESS USER NEEDS

## 3.1 Introduction

In the effort to fully understand the Army MAP and how OWL issues are addressed, a review of written documents was conducted as described in Section 2 subsequent to beginning the interviews. A better understanding of the process and issues was obtained by talking to the people who are actually involved in the process. The purposes were to further our understanding of the Army MAP and learn how OWL is currently considered. These discussions provided the opportunity to identify the concerns of the Army community with respect to: workload (and related items they cared to share); what guidance or tools would be most helpful to them; and how things actually worked as opposed to the written descriptions that had been reviewed.

This section will describe our approach to obtaining information about Army user needs and will report the information obtained. With the exception of the information received via the questionnaires (see Section 3.4), the information presented has been obtained from discussions and has been integrated to reflect general concerns and suggestions, rather than identifying specific users and their comments. This section overviews: our approach; user concerns as expressed in discussions and questionnaires; user suggestions concerning the consideration of OWL during the MAP; as well as the handbooks to be produced during this contract effort. Finally, plans for follow-up assessment of user needs will be discussed.

## 3.2 Approach

### 3.2.1 Army Organizations Visited

The Army organizations with whom we spoke and the date(s) visited are presented in Table 3.2.1-1. In addition, the DoD HFE Test and Evaluation Technical Advisory Group was briefed on 7-8 Apr 87 at NASA-Langley, VA. Researchers at NASA-Langley also briefed us regarding their recent and continuing work in the area of mental-state estimation. Their work relates directly to workload assessment and will be included in our Task 3

Table 3.2.1-1 Army Organizations Visited

| Date | Organization |
|---|---|
| 1 Apr 87 | U.S. Army Materiel Command<br>Alexandria, VA |
| 1 Apr 87 | U.S. Army Soldier Support Center -- National Capitol Region<br>Alexandria, VA |
| 2 Apr 87 | U.S. Army Operational Test and Evaluation Agency<br>Falls Church, VA |
| 6 Apr 87 | Department of the Army Armored Family of Vehicles Task Force<br>Ft. Eustis, VA |
| 16 Apr 87 | U.S. Army Test and Evaluation Command<br>Aberdeen Proving Ground, MD |
| 21 Apr 87 | U.S. Army Aviation Systems Command<br>St. Louis, MO |
| 23 Apr 87 | U.S. Army Aviation Center<br>Ft. Rucker, AL |
| 5 May 87 | U.S. Army Armor School<br>Ft. Knox, KY |
| 6,7 May 87 | ARI Field Unit Representatives from Ft. Bliss and Ft. Huachuca<br>Ft. Bliss, TX |

review. Altogether, a wide range of approximately 120 individuals were contacted, including TRADOC, AMC, and other independent agencies.

### 3.2.2 Conduct of Discussions

Initial contact with the organizations was made by the COR and visit dates and times were arranged. Following introductions at the meeting site, a 25-minute briefing was given by a member of the Analytics team to introduce our effort and explain the purpose of the meeting. The briefing typically included:

- Introductory remarks
- What is OWL?
- The importance of OWL in the Army
- OWL program objectives
- Our approach: user inputs; matching model; handbooks
- Candidate System Selection Criteria

Upon completion of the briefing (or during as appropriate), the floor was opened for questions and comments. The discussions focused on whether OWL is considered in their organization; if so, how it is considered; what guidance and tools are needed; and any suggestions for the products (handbook outlines). The second focus of discussion was on any emerging systems that the participants were aware of that would be good candidates for validation of operator workload measures. The selection of systems is later described in Section 5.

### 3.2.3 Questionnaire Distribution

Questionnaires and handbook outlines were distributed at the conclusion of each meeting. Participants were asked to distribute them to appropriate individuals within their organization and return the completed questionnaires to Analytics. A sample questionnaire is included in Appendix A. (The handbook outlines are discussed in Section 4.).

## 3.3 Army Community Concerns

### 3.3.1 What is OWL?

A common point of discussion in the meetings held was what exactly operator workload implied. There seemed to be an understanding of the problem of increasing technology and decreasing personnel resources causing increased cognitive operating requirements. However, there does appear to be uncertainty about the meaning of the term " workload." The diverse concerns included:

- Is workload based on the number of tasks to be performed?
- Does the workload issue revolve around the scarcity of Cat I (i.e., high ability) soldiers and the necessity of using Cat IVs? How do MOSs relate?
- Is workload physical , mental or both?
- How is maintainer workload related to operator workload?
- How does workload relate to MANPRINT? Is it the same as MANPRINT?

### 3.3.2 Organizational Concerns

The Materiel Acquisition Process consists of many organizations (both government and contractor) performing a series of sequential steps to achieve the goal of fielding effective and suitable equipment to accomplish a mission. The sequential nature of the process assumes the previous steps have been adequately accomplished in order for the next steps to be performed. As a result of the nature of the MAP, many comments expressed in our discussions were concerned with collection and use of the system-relevant information that has been produced previously in the MAP. A second major area of concern was resources. The resources include the people to do the required work, the expertise needed to do the work, the time in which to accomplish the work, and the money with which to pay for it. Both of the major areas of concern can be summed up in the expression that was heard in both TRADOC and AMC organizations "TRADOC doesn't do its job up front, but AMC has all the money." This expresses the frustrations that: (1) many of the important decisions impacting performance and OWL (such as crew size and operational capability) are determined very early in the MAP (as in the requirements documents) but (2) TRADOC does not always have the resources or information to make

knowledgeable decisions during this period. These decisions and requirements are the ones that will subsequently drive the design and development of the system.

There seems to be a consensus that OWL is currently addressed in a reactive mode. Only after it has been identified as a problem, or potential problem, is any action taken. There is awareness that a continuous process of addressing OWL throughout the MAP would enable the players to control OWL in a proactive manner.

The people involved with specific systems (e.g. TRADOC System Managers (TSMs) and action officers in Program Manager shops) are aware of potential workload problems but don't have the guidance, the expertise, an approach, or the necessary financial resources to adequately address OWL. Increasingly, they are looking toward the U.S. Army Research Institute (ARI) and the U.S. Army Human Engineering Laboratory (HEL) for direction in areas concerning human performance. The MANPRINT officer is also seen as a resource for both human performance and OWL concerns, however, often the MANPRINT officer has not been on the job very long and does not have a great deal of experience. The systems people are looking for whatever help they can get, and often there is only one ARI or HEL resource person with more work than one person can realistically accomplish.

Specific comments were made concerning the Required Operational Capability (ROC). A concern, particularly of testers and evaluators, was that the ROC does not provide sufficient specifics concerning human performance upon which to base test and evaluation criteria. It is difficult for them to know if there is a workload problem, or a potential problem, when there are inadequate measures of effectiveness (MOEs) and no specified levels of performance in the ROC. Certainly there is some form of evaluative judgment involved in identifying potentially excessive workloads, but there is frustration in the latter portion of the MAP in the test and evaluation area. Those involved with evaluation particularly feel that a good job is not being done in thinking about the human performance issues in the front end of the MAP in casting the requirements documents.

A second comment on the ROC was that firm decisions regarding crew size (i.e., reduced crew size) are being included, apparently without front-end analysis being done that would give information concerning the reduced crew capability. A comment made in one discussion suggested that the Army should design the capability of the equipment

around the capability of the crew (with its size, intellectual and physical abilities limitations) rather than fitting the crew to the operational wish-list of the equipment.

Another concern was that the data expected to exist do not always exist. Because of the resource constraints at the combat developer schools, such things as task lists and ECAs are not always developed in a timely way (if ever). Concern was raised that if any additional paperwork or analyses for OWL are required, that they probably wouldn't be done either. Some felt that no matter how useful and beneficial the analyses might be, there will be some resistance to doing them based on resource constraints as well as bureaucratic inertia.

### 3.3.3 Major OWL Needs

The major OWL needs identified from our meetings with Army personnel are the following:

- The need for OWL assessment techniques that will provide pertinent OWL information so that ROCs will provide a better framework for all subsequent system design work as it relates to human performance considerations.
- The need for OWL assessment techniques that are not heavily dependent upon extensive resources and expertise.
- The need for an OWL overview pamphlet that orients Army personnel to the concept, its importance, its relationship to MANPRINT, who should be concerned about it and when.

### 3.3.4 Projected Needs

When the discussions turned to anticipated or projected needs concerning assessment of operator workload, there were two basic categories mentioned. The first was the new emphasis on ASAP and NDI as the acquisition strategies of choice. The streamlined process basically requires the quality of development work to be done in a more compressed time frame. Therefore, it will be even more critical that the requirements are well conceived and front-end analyses are done so that the development can be expedited without running into design problems. The NDI strategy presents new problems in that the only opportunity to ask questions or obtain data is in the market survey process. There will be no opportunity for testing until after an initial purchase. Within the market

survey, information can be requested from vendors, but there is no assurance that the vendor has even thought about the workload issue or that any data pertaining to the issue will be available to the government. Perhaps, as soldier-in-the-loop performance issues become more important (e.g., through emphasis on MANPRINT), such issues and how they have been handled by the vendors will be seen as selling points.

MANPRINT was also seen as a driver in anticipated needs for OWL assessment. The requirements for inclusion of MANPRINT in the ROC (AR 71-9), the required SMMP, and all the other efforts to institutionalize MANPRINT in the MAP are seen as driving new needs for data and analyses concerning soldier-in-the-loop. The needs are particularly seen early in the process in the analytical arena. However, TRADOC plans on doing more testing through its Force Development Test and Evaluation (FDTE) testing program. Early testing issues will become of more interest and importance.

### 3.3.5 Identified OWL Problems

Our meetings with Army personnel resulted in a common concern being voiced about OWL. That is, the potential for excessive cognitive/mental workload demands being placed on operators as a result of innovative software systems. These new software systems have automated many of the functions previously done by operators as well as provide functionality not previously possible (e.g., new information). As a result, operators' jobs have changed to being "managers of information" whereby the requirements placed on the operator are to manage and digest the information provided via software systems and make decisions based on such information. This concern for excessive cognitive/mental OWL was expressed, in general terms, without specific reference to existing systems per se but was foreseen as a problem with future developing systems and proposed improvements to systems. Section 5 in this report describes the prototype systems that have been identified as candidates for the OWL assessment phase of this project. We have selected prototype systems that are indicative of this general concern for OWL.

### 3.3.6 Other Workload Initiatives

The issue of OWL is being addressed on several different fronts by various groups. These include Army agencies that are addressing future design of system concepts (Army HEL Crew Reduction Modeling Study) as well as theoretical issues concerning OWL (Army HEL Stress Program). Also, NASA Langley Research Center at Langley, VA is exploring OWL in aviation systems by means of mental states estimation. We have made contact with these groups and have exchanged ideas concerning our effort as well as theirs. Below are brief descriptions of these programs objectives as well as their stage of progress.

We will continue to identify other OWL initiatives so to keep abreast of the latest developments in the field and evaluate the applicability of these initiatives to our program.

- Army HEL: Crew Reduction Modeling Study, Aberdeen Proving Ground, MD. HEL is the beginning stages of developing a computer-driven mathematical model to evaluate the feasibility, desirability, and effectiveness of reducing the size of combat vehicle crews (e.g., tanks). They are in the process of selecting an outside contractor for computer modeling of combat crew operation (Sept 87).
- Army HEL: Combat Stress Program, Aberdeen Proving Ground, MD. A multi-disciplinary research program has been started to provide basic human and weapon systems performance data under "combat-stress" conditions by means of modeling the battlefield conditions that soldiers are subjected to. This is a 4-phase program that is presently in Phase I. In Phase I, efforts are underway to determine which "stress indices" are likely to reflect the effects of acute exposure to stress (i.e., battlefield conditions) in test participants and are likely to work best in simulating such conditions in the laboratory.
- NASA Langley Research Center: Mental States Program, Langley, VA. NASA has just started a 5 year program whose initial objectives are to identify physiological indices that reflect "mental states" such as fatigue and boredom which have been shown to influence operator performance. Ultimately, these physiological signs will be monitored by sophisticated software systems during aircraft flights in order to identify the points in time when software intervention is needed for maintaining flight performance.

## 3.4 Questionnaire Results

Nineteen people have fully responded to the survey questionnaire to date. Though this is a relatively small sample, the data provide a basis for discussion concerning the

Army needs for guidance on OWL. A copy of the survey questionnaire can be found in Appendix A.

### 3.4.1 Demographics

Nine respondents were civilians who worked for Army organizations such as TRADOC, ARI and HEL while the remaining ten respondents were military personnel who performed various roles in the MAP, (e.g., TRADOC assistant system manager).

With respect to functional roles, eight respondents indicated they have MANPRINT responsibilities/functions that support TRADOC schools (n=2), TRADOC integrating centers (n=2), and test and evaluation agencies (n=4). The remaining eleven respondents were TRADOC project officers (n=2), TRADOC assistant system managers (n=2), and representatives from ARI (n=3), HEL (n=1) and TRADOC integrating centers (n=3).

The nineteen respondents as a group represent integral players in the MAP who can contribute toward addressing OWL during system development. The major organization not adequately represented in this sample was materiel developers (AMC). Our future plans are to include an adequate sample from AMC.

### 3.4.2 Operator Workload (OWL)

The questionnaire contained specific questions on the importance of OWL with respect to respondents' work (present and future), the means they use now to address OWL and future directions (guidance) needed to address OWL. The results were somewhat surprising.

When asked how often the issue of OWL should be considered in their work, a majority of respondents (n=13) stated "often" (based on a 4 choice category scale - "often", "sometimes", "rarely" or "never"). In addition, respondents foresaw a greater emphasis on addressing OWL in their work for several reasons. Almost all respondents (n=17) saw changes in requirements (i.e., MANPRINT) as a force in directing their future efforts toward addressing OWL. Also, a large majority (n=16) saw "changes in technology" with respect to system innovations as an important factor in directing their work efforts to addressing OWL. Based on such an overwhelming consensus that OWL is an important

issue to be addressed in their work, one would anticipate respondents would employ similar methodologies/tools to address workload; this was not the case. When respondents were asked to state the specific guidance (documents) they use to address OWL, eleven (11) people stated they have no source document for addressing OWL issues. The remaining eight (8) respondents gave assorted answers such as ECA, HARDMAN, OWL studies in journals, and operator task lists when available.

When respondents were asked how they would like to address OWL, answers varied between respondents. For example, some offered no suggestions (n=5). Other respondents stated that specific organizations should address OWL but not "my" organization (n=3). The remaining eleven respondents gave individual answers such as more resources devoted to OWL issues, better defined ROC documents with respect to human performance, videotaping operators performing task scenarios, task analysis, objective performance measures, and physiological measures.

When respondents were asked to state the guidance they would like to have for addressing OWL, several suggestions were offered. These were:

- Standardized methodology/tool for addressing OWL that requires minimal resources, it is non-intrusive, in real time and characterized as objective in nature (n=4)
- Training course on what OWL is and how to address it (n=2)
- Local points of contact (POC) for OWL (n=2)
- OWL Handbook for writing ROC documents (n=1)
- How to raise funds to address OWL (n=1).
- Preparation of a MIL-H-46855 Workload DID (n=1)

Based on these findings, it seems apparent that Army personnel are concerned about addressing OWL in their work, however, there seems to be a lack of uniform direction and understanding with regard to what OWL is, how to address it, and where might one find answers to these questions.

### 3.4.3 Respondents' Work Responsibilities during the MAP

The survey contained a series of questions to profile the work done by Army personnel as it relates to the MAP. Questions pertained to identifying major work

responsibilities, the inputs and outputs to such work as well as the sources of information used to accomplish this work.

Table 3.4.3-1 lists the major areas of responsibilities stated by respondents. Almost half of the respondents (n=9) indicated having several overlapping responsibilities during the MAP, (i.e., they responded to more than one category).

Table 3.4.3-1 Responsibilities/roles during the MAP that are held by respondents

| Responsibility/Role | Number of Respondents |
|---|---|
| Define or review requirements, standards, criteria | 10 |
| Develop or monitor the design of emerging system concepts | 8 |
| Design or monitor the characteristics of early prototype systems | 7 |
| Test & evaluation of systems (early, mid-term, late) | 7 |
| MANPRINT (R&D) | 2 |

As seen in Table 3.4.3-1, most respondents' responsibilities are centered in the early portions of the MAP. Their roles are seen as critical for identifying OWL issues early in the MAP such that OWL can be addressed in a proactive mode. This is further exemplified by the fact that the recipients of their work are integral players in the MAP. Table 3.4.3-2 shows the major organizations and functional roles who are the recipients of the work accomplished by the survey respondents. Some respondents indicated having several recipients of their work.

Table 3.4.3-2 The major organizations and functional roles who are the recipients of the work produced by survey respondents

| Organizations/Functional Roles | Number of Respondents |
|---|---|
| TRADOC Schools (e.g., combat developers) | 7 |
| Army Materiel Command (e.g., materiel developers) | 7 |
| Test & Evaluation Organizations (e.g., OTEA) | 5 |
| TRADOC Headquarters | 2 |

In summary, the respondent's responsibilities and their associated work are an integral part of the MAP and serve to direct all future work that occurs during system development. But, the respondents lack standard methodologies/tools to address OWL issues as seen by their answers to questions about OWL.

### 3.4.4 Sources for Information

With respect to fulfilling their job responsibilities, respondents listed the Army documents as well as agencies that they referred to or seek guidance. We were interested in identifying these sources in order to understand the types of information and guidance sought by respondents. Such information would provide insights to the work issues that respondents felt were important but lack the knowledge or experience to address these issues solely by themselves. Table 3.4.4-1 lists the major sources of such guidance. Most respondents used multiple sources.

Table 3.4.4-1 Major sources for information and guidance that are used by respondents to fulfill their job responsibilities

| Organizations | Number of Respondents |
|---|---|
| Army Research Institute (ARI) | 11 |
| Army Human Engineering Laboratory (HEL) | 7 |
| TRADOC Headquarters | 6 |
| TRADOC Schools (e.g., TRADOC system manager) | 4 |
| Directorate of Combat Development | 3 |
| Test & Evaluation Organizations (e.g., OTEA) | 2 |

| Documents | | Number of Respondents |
|---|---|---|
| DOD Directive 5000.3 | Test & Evaluation | 4 |
| AR 602-2 | MANPRINT | 11 |
| AR 70-10 | Test & Evaluation | 5 |
| AR 71-3 | User Testing | 4 |
| AR 71-9 | Materiel Objectives & Requirements | 4 |
| AR 70-8 | Personnel Performance & Training | 2 |
| MIL STD 1472-C | Human Engin. Design Criteria for Military Systems, Equipment, & Facilities | 3 |
| HARDMAN | (Hardware vs. Manpower Compar. Anal.) | 1 |
| ECA | (Early Comparability Analysis) | 1 |

Clearly, the respondents' sources for information (e.g., ARI, MANPRINT) reflect their concern to address human-related issues (i.e., human performance). It is of interest to note that the documentation sought for guidance contains minimal information on OWL.

### 3.4.5 Performance Issues with respect to the Total System Development Process

The survey contained a series of questions to ascertain the different performance areas that respondents consider in order to do their job. Table 3.4.5-1 summarizes participants' responses to four major performance areas. Listed are the number of respondents who responded to a 4-choice category scale ("often", "sometimes", "rarely", or "never") by checking the "often' category with respect to these performance areas. Table 3.4.5-2 summarizes participants' responses to major human performance areas. Listed are the number of respondents who responded to a 4-choice category scale ("often", "sometimes", "rarely", or "never") by checking the "often" category with respect to these performance areas.

Table 3.4.5-1 Number of respondents who stated that they "often" consider these performance issues in their work

| Performance Area | Number of Respondents |
|---|---|
| Total System Performance | 16 |
| Subsystem Performance | 10 |
| Operator Performance | 16 |
| Maintainer Performance | 13 |

Table 3.4.5-2 Number of respondents who stated that they "often" consider these human performance areas in their work

| Human Performance Area | Number of Respondents |
|---|---|
| Human Factors Engineering | 14 |
| Manpower | 11 |
| Personnel | 13 |
| Training: Individual soldiers | 16 |
| Training: Unit | 8 |
| Safety | 11 |
| Health Hazards | 10 |

It is quite evident from these results (Table 3.4.5-1, & Table 3.4.5-2) that performance issues (total system and human element areas) are given consideration by respondents.

### 3.4.6 Conclusions

The results of the study show that respondents are aware and concerned about human performance areas. However, a standardize methodology/tool as well as a single source for information addressing OWL is lacking. It also seems apparent that respondents' lack of clarity in their answers to specific questions about OWL (e.g., no responses) indicate a fuzziness on what is meant by OWL and how to address it. This finding is very revealing as the respondents to this survey have ideal positions from which to address OWL throughout the MAP.

## 3.5 User Suggestions for OWL Program in Army

Within the context of the discussions with users, a number of suggestions were given as to what the users thought would be most useful to Army users. Although most of the suggestions have already been touched upon, a separate listing was thought to be helpful. The items are not in any specific order. The suggestions are:

- Integrate with the MANPRINT effort to ensure success.

  It was recognized by many with whom we spoke that to assure implementation of any OWL guidance that was developed, some type of regulatory emphasis was needed. The most practical suggestion was that the MANPRINT requirements (e.g., SMMP) be used as the vehicles to address OWL concerns.
- Guidance must accommodate limited resources and expertise available.
- Make the cognitive/mental aspects of OWL the explicit focus of the project.
- Capitalize on any existing information or data that relates to OWL.

  Information is generated and analyses performed to make decisions in the current MAP. Before attempting to require more data and information generation, be sure to examine what is already available to see if it might be useful in answering OWL questions.
- Both TRADOC and AMC must be receptive to this effort. To get the most benefit, both must be involved in OWL assessment and control.

- Create an associated OWL DID.

  There is an awareness that contractors will be in the correct place to gather data relevant to OWL. In order to capture those data, as well as assuring that an appropriate methodology is being followed, create a Data Item Description so that there is a means to obtain data from the contractor during system design and development.

- Have awareness that contractors may be ones to use the developed OWL guidance.

  Early analyses that requires technical expertise or more man-hours that internally available may be contracted out. Similarly, the realization that the RFP is the most appropriate place to require OWL assessment.

## 3.6 User Suggestions for OWL Products

The users made several suggestions regarding the handbooks to be produced. The suggestions are:

- Computer-based mode of presentation.

  The users questioned the use of written material (i.e., handbooks). Their experience has been that there is a tendency to just put handbooks on a shelf and not use them. The suggestion was that guidance, particularly the predictive and evaluative handbooks, created on an on-line, interactive, computer-based system might be better and easier to use.

- Pamphlet should be used to institutionalize the concept of OWL.

  Many integral players in the MAP do not consider soldier-in-the-loop when developing system concepts and designs. The pamphlet may be useful to draw attention to the soldiers' performance aspects of system performance and to advise managers to raise flags when an OWL problem may be involved.

- Two recommendations should result from our guidance for selecting specific OWL techniques.

  Recommendations: 1) a minimum assessment battery for low-resource applications , and 2) a more complete battery of OWL techniques for circumstances where more resources are available.

## 3.7 Conclusions and Recommendations

Several conclusions can be drawn from the discussions that were held:

- Within the Army community, there is real concern about OWL but there seems to be lack of conformity in how to address it. Everyone seems to have their own way of doing it or ignoring it.
- There was skepticism of any project as wide-reaching (i.e., going across organizational boundaries) as this one.
- It is important for us to keep abreast of other Army initiatives concerning operator workload.
- Any program or methodology developed has to be sensitive to resource limitations.
- The methodology must be able to accommodate the ASAP, NDI, and other acquisition strategy procedures.

### 3.8 Follow-on Interview Plans

Those individuals in Army organizations with whom we spoke provided useful information. We will continue our discussions with them throughout the project as appropriate for later follow-ups. Current plans are to keep them apprised of the project progress and to consult with them again in the future concerning the handbooks. Since our primary goal is to provide useful information in the most appropriate format, the Army community of users will be consulted regarding the development of the handbooks.

# 4. OUTLINE OF FINAL PRODUCTS

## 4.1 INTRODUCTION

In the original statement of work (SOW), five major areas were identified to be addressed by a set of handbooks which Army personnel would use for making decisions on OWL during the materiel acquisition process (MAP). These areas were:

- How and where to use handbooks
- Guidelines for how to estimate OWL, including how to select the most appropriate measures of OWL for a given new system design
- Guidelines for evaluating OWL during concept and evaluation, and developmental and operational testing
- Alternative methods for reducing excessive OWL in Army systems, and
- Recommendations for selecting among or prioritizing those alternative OWL reduction methods.

These five major areas were originally proposed to be covered by three related products: an overview pamphlet for the TRADOC community on OWL, and two handbooks addressing OWL techniques, one to be used during the early phases of the MAP (pre-Milestone 1 activities) and the other to be used during system development phases of the MAP (post-Milestone 1 activities).

To ensure these products are successfully received by the Army community, we developed draft outlines depicting each product's content as well as descriptions of the rationale for each section covered. These outlines were used to elicit Army personnel comments and reactions in order to ascertain their specific needs concerning OWL and to "shape" the final handbook products. It was the first step in our ongoing and iterative development of user-oriented products. Examples of the draft outlines that were discussed in the interviews with Army personnel may be found in Appendices B through D.

Based on meetings with Army personnel, we identified two major concerns that needed to be addressed in all the OWL products to ensure their successful use and incorporation into the work activities of the intended users of these products.

- A thorough description of what operator workload is, the importance of OWL as a significant determinant of system performance, and how it relates to system requirements and design issues.

- A descriptive framework to show the integration between existing Army requirements (e.g., MANPRINT requirements) and other Army programs (e.g., HARDMAN) and the approach prescribed in the handbooks. How the OWL program complements and supports these existing Army programs.

Besides these overall considerations, each outline elicited specific comments and suggestions. These user reactions will be discussed in the respective subsections for each proposed product.

## 4.2 TRADOC PAMPHLET

### 4.2.1 Original Concept in Statement of Work (SOW)

The TRADOC overview pamphlet was originally conceived as a guide for TRADOC personnel "to incorporate workload in the ROC (Required Operational Capability)". This pamphlet was seen as an overview that described what is meant by OWL and how to address it in a ROC . It would highlight the issues of OWL such that TRADOC managers, (i.e., combat developers), could recognize the need to address OWL in ROC documents and assist them to make provisions (e.g., requirements) for its adequate assessments in subsequent phases of the MAP.

### 4.2.2 Rationale for Original Draft Outline and Revision

Our original draft outline expanded the scope of the pamphlet. We envisioned the pamphlet providing an overview emphasizing the need to address OWL throughout the MAP such that managers in TRADOC and AMC who are in positions to oversee the development of systems would have the proper framework to address OWL throughout the cycle. Otherwise, issues that relate to OWL could be overlooked as the MAP progresses. Such an emphasis on OWL throughout the MAP would provide the correct orientation for OWL to be addressed in a proactive mode as opposed to a reactive mode of fixing past mistakes attributed to excessive operator workload. The original pamphlet outline dated 9Feb87 is found in Appendix B.

Based on our discussions with Army personnel who are involved with various phases of the MAP, it became apparent that the pamphlet should go beyond our original

conceptualization with respect to our intended audience. That is, there seemed to be a lack of awareness and/or concern that OWL is an important issue to be addressed throughout the MAP.

As a result, the pamphlet needs to address OWL such that all integral players in the MAP (e.g., TRADOC, AMC, OTEA, AMSAA, and TECOM) are aware of the importance of addressing OWL throughout the MAP since all can contribute to preventing OWL problems. To do so required revising our initial pamphlet outline such that ALL key personnel in the MAP would be oriented to conceptualizing, developing and evaluating systems with OWL as a major consideration. This is especially true today since new technologies (automation via software innovations) and projected manpower reductions are placing a potentially heavier burden on operators to mentally perform new operations that can directly impact system performance. We have revised the manager's pamphlet outline to reflect this orientation toward OWL so ALL Army personnel involved in system development realize the coordinated effort needed across organizations to ensure that OWL is addressed in a proactive mode. The revised pamphlet outline dated 23May87 follows this subsection.

# REVISED MANAGER'S OPERATOR WORKLOAD ASSESSMENT PAMPHLET

## OUTLINE

USER PROFILE: The intended users for the pamphlet are the managers who are involved in both delineating the needs, and developing the requirements for a new system as well as those involved in evaluating system performance in which the soldier-in-the-loop is considered an integral part of the evaluation. This user is not interested in the details of workload estimation or evaluation. What IS of interest to these managers is high-level guidance on what are the Army requirements regarding workload, and what high-level provisions should be built into the system acquisition strategy for the assessment of OWL. The orientation of this pamphlet is to instill the concept of operator workload (OWL) in the everyday vocabulary of managers such that it is addressed in a proactive mode throughout the MAP. This can only happened if ALL managers, irrespective of organizations, are attuned to the importance of OWL as a major factor contributing to overall system performance. Each manager has a role in ensuring that OWL does not adversely affect overall system performance.

FORMAT: This Pamphlet will be structured to provide a concise, easily understood presentation of the role of OWL control in the materiel acquisition process (MAP). Tables, charts, flow diagrams, and specific examples will be used liberally to promote quick apprehension of concepts.

GOAL: Provide the reader with an overview of the role of OWL control in the materiel acquisition process, including the nature of the problem, DoD/DA documents and requirements concerning OWL control, and available technologies to assist ALL Army managers (e.g., TRADOC, AMC, OTEA, AMSAA, and TECOM) in ensuring OWL control. Provide guidance in accessing other OWL control resources, especially the OWL Prediction and Evaluation Handbooks.

LENGTH: approximately 40-50 pages

## I. INTRODUCTION

A. Definition of Operator Workload (OWL)

B. Traditional factors attributed to OWL, e.g., physical involvement of operators

C. New technologies affecting system concepts, e.g., automation via software

D. New factors attributed to OWL, e.g., mental/cognitive involvement of operators

E. Impact of OWL on Army Mission Functions

F. Army requirements, specifications, standards and regulations for OWL

G. Relationship of OWL to MANPRINT Program

H. Contribution of ALL managers involved with the MAP in addressing OWL

I. Description of the contents of this pamphlet, how to use this pamphlet

STRATEGY: Introduce managers to the key OWL concepts and regulations. Provide the proper framework on how to use this handbook.

## II. OVERVIEW OF OWL FUNDAMENTALS

A. OWL Performance Model - factors contributing to workload.

B. OWL with various types of actions/behaviors that are mental/cognitive in nature

1. Searching for and receiving information
2. Identifying objects, actions, events
3. Problem solving
4. Decision making

C. OWL considerations for system types with respect to Mission Areas

D. OWL considerations during the Materiel Acquisition Process (MAP)

1. Accelerated Systems Acquisition Process (ASAP)
2. Proactive mode vs. reactive mode in addressing OWL
3. Key questions concerning OWL to be addressed throughout the MAP

E. OWL Assessment Program

1. Prediction (analytic approach)
2. Evaluation (empirical approach)
3. Analysis of results - addressing key OWL questions as revealed by analysis of one's results/data

F. OWL Control Plan

STRATEGY: Provide a global "mental map" for the user on the key areas and steps involved in OWL prediction/evaluation and its relationship to the materiel acquisition process.

## III. OWL IN REQUIREMENTS ANALYSIS/CONCEPT FORMULATION

A. TRADOC perspective - combat developers

B. AMC perspective - program managers

C. Evaluators/testers perspective

D. OWL trade offs in concept formulation

E. Development of a preliminary OWL Control Plan

F. Key OWL resources

1. Documents
2. Organizations (e.g, HEL, ARI)
3. Individuals (e.g., HFE specialists)

G The TRADOC Manager's OWL Concept Formulation Check List

1. What should the TRADOC combat developer be ensuring is accomplished.

H. The AMC Manager's OWL Concept Formulation Check List

1. What should the AMC program manager be ensuring is accomplished.

STRATEGY: Provide the user a step-by-step approach to developing and managing an OWL Control Plan during requirements analysis and concept formulation. Provide the manager the knowledge to integrate the OWL Control Plan with existing requirements, programs, and other control plans that are part of the materiel acquisition process.

## IV. OWL IN SYSTEM DEVELOPMENT

A. TRADOC perspective - system managers

B. AMC perspective - program managers

C. Evaluators/testers perspective

D. The OWL Control Plan

E. Methods for assessment

1. OWL Prediction (analytic approach)
2. OWL Evaluation (empirical approach)

F. Key OWL resources

1. Documents
2. Organizations (e.g., HEL, ARI)
3. Individuals (e.g., HFE specialists)

G. TRADOC system manager's OWL Check List for OWL Prediction

H. TRADOC system manager's OWL Check List for OWL Evaluation

I. AMC program manager's OWL Check List for OWL Prediction

J. AMC program manager's OWL Check List for OWL Evaluation

K. Testers/Evaluators Check List for OWL Prediction

L. Testers/Evaluators Check List for OWL Evaluation

STRATEGY: Provide the manager a step-by-step approach to developing and managing an OWL Control Plan during system development. Provide the user the know-how to integrate the OWL Assessment Program with existing requirements, programs, and other control plans that are part of the materiel acquisition process.

## V. ITERATIVE NATURE OF OWL ASSESSMENT

A. Materiel acquisition process

B. System design decisions

C. Evolution of OWL considerations

STRATEGY: Establish the concept that the OWL Assessment Program and its management and control are evolving processes which are modified as the materiel acquisition process progresses and requires the coordination and cooperation of all Army agencies involved in the MAP.

## VI. OWL CONCERNS AND ARMY SYSTEM DEVELOPMENT ITEMS

A. Non-Developmental Items (NDI)

B. Product Improvements (P3I, PIP)

STRATEGY: Elaborate on the special circumstances these areas present for addressing OWL and emphasis the need to ensure that OWL does present itself as a problem.

## VII. EXAMPLE

A. An example will be provided that delineates the various managerial responsibilities across organizations that play a role in controlling OWL during the MAP - the development and implementation of their respective OWL Control Plans.

STRATEGY: Provide the user with a concrete example of an overall OWL Control Plan.

## VII. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

## 4.3 PREDICTION HANDBOOK

### 4.3.1 Original Concept in Statement of Work (SOW)

The Workload Prediction Handbook was originally conceived as a guide for addressing OWL during the new system concept development phase of the MAP (pre-Milestone I activities). The handbook would direct Army personnel in employing OWL predictive techniques by identifying the most appropriate predictive technique with respect to their particular needs and resources. The techniques offered would lend themselves to identifying OWL issues that need to explore and/or address in the further refinement of the system concept. Use of such techniques would give valuable direction early-on in the MAP so to minimize potential OWL problems in later phases of the MAP.

### 4.3.2 Rationale for Original Draft Outline and Revision

In general, our original draft outline attempted to provide a methodology for identifying the most appropriate predictive technique for a given system concept. It also highlighted the importance of OWL, its relationship to system performance and OWL evaluations conducted during later phases of the MAP. The original pamphlet outline dated 9Feb87 is to be found in Appendix C.

Based on our meetings with Army personnel, we identified sections in the outline that needed further clarification as well as new material to be included in the handbook. The predictive handbook needs to address and/or clarify the following:

- Greater emphasis on the significance of addressing OWL early-on in the MAP - greater likelihood of success, (i.e., incorporating OWL considerations in later design phases), as well as the most cost-effective point in time to offer suggestions for design changes (i.e., least expense involved in comparison to later phases of the MAP).
- The complementary relationship between the use of this handbook and the Army's new directive to address soldier issues early-on in the MAP - MANPRINT Program.
- The relationship between the guidance offered in this handbook and the methodologies currently used by the Army during the early portions of the MAP, (e.g., HARDMAN and ECA).
- How the results generated from the use of these predictive techniques can drive the later phases of the MAP in controlling OWL. What are the

means available to ensure this, (i.e., ROC , future test plans, DIDs, etc.).

We have revised the predictive handbook outline to reflect these changes. The revised predictive handbook outline dated 23May87 follows this subsection.

# REVISED WORKLOAD PREDICTION HANDBOOK

## OUTLINE

USER PROFILE: The Workload Prediction Handbook is intended for Army personnel (e.g., TRADOC combat developer and system manager) during the concept and early design phases of the materiel acquisition process (MAP). This user is interested in the different OWL measures and techniques applicable during early design. This user is typically the person who (1) makes the decision of which OWL assessment tools to use, and (2) adapts those tools to fit the specific needs and characteristics for the system of interest. To guide the user in performing these functions, the handbook will identify (based on system requirements and specific design objectives) the workload assessment methodology needed via a "matching model" procedure such that an optimal OWL Assessment Battery is offered. The handbook provides guidance on the identification and implementation of the OWL Assessment Battery for all types of systems.

FORMAT: This Handbook will be organized so to maximize its utility as a working document. Descriptions will be concise and to-the-point. For those users wanting additional background and supporting information, references and appendices will be provided. Decision trees, tables, and charts will be used whenever possible to assist the user in following the methodology contained in the Handbook.

GOAL: Provide the user a step-by-step approach to developing and implementing an OWL assessment program during early system development. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs (e.g., MANPRINT) , and methodologies (e.g., ECA and HARDMAN) that are used in the early phases of the materiel acquisition process (MAP).

LENGTH: approximately 75-100 pages

## I. INTRODUCTION

A. Definition of Operator Workload (OWL)

B. Traditional factors attributed to OWL, e.g., physical involvement of operators

C. New technologies and factors affecting system concepts, (e.g., automation via software)

D. New factors attributed to OWL, (e.g., mental/cognitive involvement of operators)

E. Impact of OWL on overall system performance

F. Army requirements, specifications, standards, and regulations for OWL

G. Relationship of OWL to MANPRINT Program

H. Purpose for handbook: methodology for determining and implementing an operator workload assessment program via OWL predictive techniques during concept and preliminary design phases

I. How to use this handbook; overview of contents.

<u>STRATEGY</u>: Introduce the user to key OWL concepts and requirements. Orient the user to the critical concept - OWL predictive assessment techniques are critical for identifying OWL issues such that solutions concerning OWL (overload) can be reached in a cost-effective way (proactive mode). Otherwise, potential OWL problems will probably be addressed in a reactive mode, (i.e., fixing past mistakes). Provide the framework on how to use the Handbook.

## II. OVERVIEW OF OPERATOR WORKLOAD PREDICTION

A. What is OWL prediction?

B. Relationship between methodology offered in this document and existing Army methodologies, (i.e., ECA, HARDMAN, Task Analysis)

C. The relationship between OWL prediction & OWL evaluation

D. Factors to consider for OWL prediction

1. System requirements
2. Operator capabilities/skills/behaviors required
3. OWL performance model - performance factors to consider
4. OWL assessment techniques

E. Methodology: Matching model for establishing an OWL Predictive Assessment Program

STRATEGY: Provide a global "mental map" for the user on the steps involved in workload prediction (analytic approach) and its relationship to OWL evaluation (empirical approach)

## III. OPERATOR WORKLOAD PREDICTION METHODOLOGY

A. Determine system performance requirements

1. Potential Sources:
    a. O & O Plans (Operational & Organizational)
    b. JMSNS (Justification of Major Systems New Starts)
    c. ECA (Early Comparability Analysis)

B. Determine operator actions/behaviors for system usage

1. Sources
    a. Requirement documents (O & O Plans, ROCs)
    b. Task analyses
    c. Expert opinions (SMEs)

d. Comparative systems (e.g., SMMP, ECA)

e. Mock-ups

f. Simulators

2. Classification of operator behaviors/actions required for system usage (cf., Universal Operator Behavior Dimensions - Berliner, Angell, & Shearer, 1964)

– Chart of Universal Operator Behaviors -

a. Searching for and receiving information

b. Identifying objects, actions, events

c. Problem solving

d. Decision making

D. Determine OWL performance model factors to incorporate into matching model methodology (decision making process)

E. Determine OWL assessment program

1. Decision rules for selecting an OWL predictive assessment battery
2. Decision tables for OWL methodologies that are applicable

F. Analytic assessment methods

1. Purpose: Prediction of OWL & "chokepoints"
2. Sensitivity
3. Representation of OWL issues/behaviors
4. Techniques
   a. Expert opinions
   b. Comparisons
   c. Simulations/Models
   d. Math models
   e. Task analytic methods
5. Interpretation of assessment results

STRATEGY: Provide the user a step-by-step approach to developing and implementing an OWL Predictive Assessment Program. Provide the user the know-how to integrate the OWL Assessment Program with existing requirements, programs, and methodologies that are part of the materiel acquisition process.

## IV. ITERATIVE NATURE OF OWL PREDICTION

A. Materiel acquisition process

B. System design decisions

C. How to address OWL issues in the MAP, (i.e., ROC, SMMP, and Test Plans)

STRATEGY: Establish the concept that the OWL assessment program (developed from using this Handbook) is an evolving program which will be modified as the materiel acquisition process progresses. OWL must be monitored and controlled by establishing requirements, (i.e., Measures of Effectiveness [MOEs] in the ROC), that ensure activities conducted after Milestone I address OWL issues that were identified from the use of the OWL predictive techniques.

## V. EXAMPLES

A. Examples will be provided for each of the assessment techniques.

STRATEGY: Provide the user with concrete examples of OWL predictive assessment programs. Provide reality to the OWL prediction methodology described in the Handbook.

## VI. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

## 4.4 EVALUATION HANDBOOK

### 4.4.1 Original Concept in Statement of Work (SOW)

The Workload Evaluation Handbook was originally conceived as a guide for addressing OWL during the conduct of concept evaluation, and developmental and operational testing (post-Milestone I activities). The handbook would direct Army personnel in employing OWL evaluation techniques (subjective, physiological, and objective/task measures) by identifying the most appropriate empirical technique with respect to their particular needs and resources. The techniques offered would lend themselves to be incorporated in any system evaluation effort and would complement any existing data/information on OWL collected earlier in the MAP (predictive techniques). These techniques provide data to substantiate design solutions/decisions to minimize OWL as well as direct future refinements for system design.

### 4.4.2 Rationale for Original Draft Outline and Revision

In general, our original draft outline attempted to provide a methodology for identifying the most appropriate evaluative technique for a given system during the various developmental phases phases after Milestone I activities. It also highlighted the importance of OWL, its relationship to system performance and previous OWL assessments conducted earlier during the MAP (OWL predictive techniques). The original handbook outline dated 9Feb87 is to be found in Appendix D.

Based on our meetings with Army personnel, we identified Army concerns that need to be addressed in the Evaluation Handbook. These concerns are the following:

- Emphasis on the coordination of previous OWL assessments (OWL predictive techniques) with subsequent testing and evaluation such that provisions are established (e.g., ROC, SMMP) to ensure that OWL concerns already identified are addressed adequately in the later phases of the MAP.
- Elaboration on the key roles that the various testing and evaluation agencies (OTEA, AMSAA, and TECOM) as well as system and training agencies (AMC and TRADOC) play in addressing OWL issues. All have a contribution to make in controlling OWL.
- Address the applicability of the methodology proposed in the handbook with respect to the Army's accelerated programs for system acquisition,

(i.e., ASAP and NDI), and the evolutionary development of systems, (i.e., PIP and P3I).

We have revised the evaluation handbook to reflect these concerns. The revised evaluation handbook outline dated 23May87 follows this subsection.

REVISED WORKLOAD EVALUATION HANDBOOK

OUTLINE

USER PROFILE: The Workload Evaluation Handbook is intended primarily for the Army community involved with developmental testing and evaluation (DT&E). These users are interested in interpreting the results of the various workload assessments conducted throughout the development cycle and are primarily concerned with system evaluation from many different perspectives (e.g., TRADOC, AMC , OTEA, AMSAA, and TECOM). These evaluators and users of data from test and evaluation (T&E) are also interested in how to perform OWL analysis. In addition, they are concerned with the actual constraints placed by real-world implementation of a workload assessment. Such constraints involve traditional (and non-traditional) limits on testbed resources (e.g., subjects, time, and funding). The T&E users are also concerned with how to transform OWL data and information into recommendations for system design.

FORMAT: This Handbook will be organized so to maximize its utility as a working document. Descriptions will be concise and to-the-point. For those users wanting additional background and supporting information, references and appendices will be provided. Decision trees, tables, and charts will be used whenever possible to assist the reader in following the methodology contained in the Handbook.

GOAL: Provide the user a step-by-step approach to developing and implementing an OWL assessment program. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs, and methodologies that are part of the military system acquisition cycle.

LENGTH: approximately 125-150 pages

## I. INTRODUCTION

A. Definition of Operator Workload (OWL)

B. Traditional factors attributed to OWL, (e.g., physical involvement of operators)

C. New technologies and factors affecting system concepts, (e.g., automation via software)

D. New factors attributed to OWL, (e.g., mental/cognitive involvement of operators)

E. Impact of OWL on overall system performance

F. Army requirements, specifications, standards, and regulations for OWL

G. Relationship of OWL to MANPRINT Program

H. Purpose for handbook: methodology for determining and implementing an operator workload assessment program via OWL evaluative techniques during concept evaluation and developmental and operational testing.

I. How to use this handbook; overview of contents.

STRATEGY: Introduce the user to the key OWL concepts and requirements. Orient the user to the critical concept - OWL Evaluative Techniques are crucial for determining the feasibility of design decisions as they relate to minimizing OWL. Provide the proper framework on how to use the handbook.

## II. OVERVIEW OF OPERATOR WORKLOAD EVALUATION

A. What is OWL evaluation?

B. Who is involved? (TRADOC, AMC, OTEA, AMSAA, TECOM, )

B. The relationship between OWL evaluation & OWL prediction

C. Factors to consider for OWL evaluation

1. System requirements
2. OWL assessment program constraints
   a. Subjects
   b. Time
   c. Funding
   d. Etc.
3. Operator capabilities/skills/behaviors required
4. Earlier OWL assessments (OWL prediction)
5. OWL performance model - performance factors to consider
6. OWL empirical assessment techniques

D. Methodology: Matching model for establishing an OWL Evaluative Assessment Program

STRATEGY: Provide a global "mental map" for the user on the steps involved in workload evaluation (empirical approach) and its relationship to OWL prediction (analytic approach), and system design.

## III. OWL ASSESSMENT (TEST AND EVALUATION)

A. Determine system performance requirements

1. Sources
   a. Requirement documents (ROC, and O & O Plans)

B. Determine operator actions/behaviors for system usage

1. Sources
   a. Task analyses
   b. Expert opinions
   c. Comparative systems
   d. Mock-ups

e. Simulators

2. Classification of operator behaviors/actions required for system usage (cf., Universal Operator Behavior Dimensions - Berliner, Angell, & Shearer, 1964) - Chart of Universal Operator Behaviors -

   a. Searching for and receiving information

   b. Identifying objects, actions, events

   c. Problem solving

   d. Decision making

C. Determine stage in materiel acquisition process

D. Determine OWL performance model factors to incorporate into matching model (decision making process)

   1. For example, environmental factors such as noise, vibration, heat, and cold

E. Determine OWL assessment program

   1. Decision rules for selecting an OWL Assessment battery

   2. Decision tables for workload methodologies that are applicable

F. Establish framework for the evaluation

   1. Task scenarios

G. Empirical Assessment Methods

   1. Purpose: Evaluate design decisions

   2. Sensitivity

   3. Task scenarios: representation

   4. Techniques

      a. Operator opinion

      b. Primary task

      c. Secondary task

      d. Physiological responses

   5. Interpretation of assessment results to impact system design

<u>STRATEGY</u>: Provide the user a step-by-step approach to implementing an OWL evaluative assessment program - test and evaluation. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs, and methodologies that are part of the materiel acquisition process.

## IV. ITERATIVE NATURE OF OWL EVALUATION

A. Materiel acquisition process (MAP) and Accelerated acquisition process (ASAP)

B. System design decisions

C. Army agencies involved in the iterative nature of OWL assessment - (TRADOC and AMC as key players )

STRATEGY: Establish the concept that OWL assessment (test and evaluation) is an iterative process that is conducted throughout the materiel acquisition process to ensure OWL is not a system problem.

## V. OWL CONCERNS AND ARMY SYSTEM DEVELOPMENT ITEMS

A. Non-Developmental Items (NDI)

B. Product Improvements (e.g., P3I, PIP)

STRATEGY: Elaborate on the special circumstances these areas present for addressing OWL and show the applicability of the methodology represented in this handbook to these set of circumstances.

## VI. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

# 5. SELECTION OF REPRESENTATIVE SYSTEMS

## 5.1 Introduction

The three representative system selected during the present effort are crucial to later efforts. They provide the test-bed upon which the validation of OWL measures and methodology will be later conducted (Task 4). In addition, these also provide the framework for illustration of applications which will augment of the documentation of our methods (OWL Handbooks) which will be subsequently be prepared (Task 5). Beyond thishowever, it is intended that the analyses of the prototype systems will provide significant benefits for their development and the Army. Delineated in the following are: the selection methodology (5.2), description of the selected systems (5.3), and brief discussion of on-going efforts (5.4).

## 5.2 Methodology

A two-stage approach was applied for selection of representative systems based upon Interview Inputs and Army Sponsor Guidance.

### 5.2.1 Interview Inputs

The first stage involved identification of candidate systems during our interviews of potential users and cognizant personnel within the Army (cf., Sect.3.2). Typically subsequent to description of the OWL Assessment Program, interviewees were presented with candidate system selection criteria. Most salient of these were requirements to: (1) select candidates requiring the broad range of predictive and evaluative OWL techniques and (2) select systems which could be realistically impacted within the time frame of the program efforts. The first of these, it is noteworthy, was reflected in interest with systems in different phases of the materiel acquisition process, and under different combat developers consequently representing a range of systems.The second requirement pointed toward systems undering rapid (NDI) or near-term changes in status. The interviews proved fruitful and pointed toward more than a dozen individual or families (e.g., AFV) of systems for joint consideration with ARI.

5.2.2 Army Sponsor Guidance

Candidates systems were weighed with respective to theobjectives and schedule of the present effort in a joint meeting 6-7 May at the ARI Field Unit, Ft. Bliss. Based upon information obtained in interview follow-ups, system candidates were first screened with respect to the program schedules of the various systems as well as assessability by the evaluation team. For surviving candidates, operators of interest were identified and evaluated. Group evaluations were made with respect to operator gross environmental exposure (impact); estimated relative levels of perceptual, cognitive, motor, and communication workload; as well as physiological workload levels imposed by manual tasks (lifting, pushing, carrying etc.). Representative systems were then selected so as to insure a range of perceptual, cognitive, motor, and communication workload levels across systems.

## 5.3 Selected Representative Systems

The selected representative systems include: (1) Line of Sight-Forward (Heavy) [LOS-F(H)]; (2) Automatic Target Handoff System [ATHS]; as well as (3) a Remotely Piloted Vehicle (RPV[AQUILA or IEW-UAV(I)]. In the following, each of these systems will initially be characterized with regard to nature, type of acquisition and status, as well as operators of interest. The comparison of the character of anticipated OWL will subsequently be overviewed across systems for the operators of interest.

### 5.3.1 LOS-F(H)

LOS-F(H) is one of five components of the Forward Area Air Defence (FAAD) System. FAAD as a whole is designed to defend force and critical assets against rotary wing and fixed wing aircraft threats during 24 hour day and night operations, a countermeasures environment, and adverse visibility and weather conditions. The LOS-F(H) component of FAAD will be a self propelled, armored, highly mobile, platform with a primary armament of launch-ready missiles as well as a complementary weapon providing full coverage of air defence within the dead zone of the missile. It is designed to provide front line air defence against attacks by high performance ground attack aircraft, attack helicopters, as well as self defence against armored vehicles and ground targets.

LOS-F(H) is being acquired under a NDI strategy aimed at fielding during 1991 which provides for evaluation of the breadth of measures of OWL. Candidate selection, Milestone I/II of the ASAP, is scheduled to be made on the basis of a competitive shoot-off to be conducted during September to December 1987. Follow-on testing of the selected candidate as will as Force Development Test and Evaluation (FDTE)is scheduled for Fiscal Year (FY) 88. LOS-F(H) has two operators of particular interest with respect to workload that may be nominally designated across system candidates as: (1) Gunner and (2) Squad Leader.

### 5.3.2 Automatic Target Handover System [ATHS]

The ATHS is designed to provide secure jam resistant digital communications and is envisioned as being a subsystem in a variety of future helicopter and other vehicles. With associated Navigation and Interrogation Friend or Foe (IFF) Subsystems, it is currently scheduled for integration into the APACHE AH-64A Aircraft (the draft RFP is under review). This integration is for facilitation of intelligent automatic digital data processing for missiles, weapons, and related information transfer between, other AH-64A, Scout Aircraft, and ground units via digital waveforms compatible with TACFIRE. For the AH-64A, the integration is to allow simultaneous operation by dual [Pilot and Copilot/Gunner (CPG)] control and display units which shall be night-vision goggle compatible. It is believed, however, that in flight the primary operator will be the CPG because of the flight control responsibilities of the Pilot. The CPG will have a message received indicator "that can be viewed/heard during all workload conditions". The CPG is the operator which has been identified for detailed workload evaluation.

### 5.3.3 Aquila/ IEW-UAV(I) Remotely Piloted Vehicles (RPVs)

The Aquila and Unmanned Air Vehicle - Intelligence Electronic Warfare (Interim) [IEW-UAV(I)] are RPV components of representative systems pointed to as having growing significance for the Army. Of these, the Aquila based system was judged somewhat more suitable for the goals of the present (OWL) effort because of its developmental maturity and history. However as it is under Full Scale Engineering Development (FSED), with an impending scheduled ASARC in June 1987, and it was deemed prudent to retain as a backup the IEW-UAV(I). Currently with broad opportunities

for the present (OWL) efforts because of its status as a NDI, the IEW-UAV(I) is being selected on the basis of an on-going flyoff and will be used for development of the specifications of final UAVs by Ft. Huechuca. Based upon initial analyses and the status of the IEW-UAV(I), it was judged that for the present purposes it could be considered analogous to (a larger) Aquila (with similar perceptual, cognitive, motor, and communication performance and workload problems). Consequently, Aquila will be delineated in the following both with regard to itself and as a surrogate for the IEW-UAV(I).

The Target Acquisition/Designation and Aerial Reconnaissance System (TADARS) Aquila RPV is an 'eye in the sky system' designed to provide the ground commander realtime battlefield information by detection, recognizing, identifying and designating enemy forces (ARI, 1987). The Acquila itself is a tailless mid-wing tactical mini-plane with a rear-mounted pusher propeller engine. Included as part of the system are a stabilized TV sensor and a laser rangefinder/designator on the aircraft, an antijam data link for communication with a ground control station, as well as personnel for operation. Basically fixed during operations, the ground control station may be noted as being located in an protected shelter in the rear of a MS14 5-Ton Truck. More interestingly, the data link may be noted as having has seven (0-6) levels of function which may impact on mission/modes(Search, Artillery and Track) performance and workload. Although more recent flight tests have implications regarding this of which we are not fully apprised (e.g., GAO, 1986; ARI, 1987, p.4), Hershberger et al., 1983 have previously reported suggestive results from "man in the loop" simulations. Aquila has three operators of which two have been identified for detailed workload evaluation:

(1) Vehicle Operator (VO) , and

(2) Mission Commander (MC).

### 5.3.4 OWL Overview For The Selected Systems

Figure 5.3.4-1 summarizes salient features of operator workload developed during the group evaluation meeting 6-7 May at Ft. Bliss (cf., 5.2.2). Examining this table, it may be seen that except for the Gunner in the LOS-F(H) (during loading operations), physiological workload is expected to relatively constant and minimal (Low). The group

judgements of perceptual, cognitive, motor, and communication workload levels may also be seen to span the range (Low-High).

## 5.4 Discussion

The three selected representative systems are the test-beds upon which the validation of OWL measures and methodology will be later conducted (Task 4). Although a large step, their selection is only the beginning of the development of an overall and system specific plans for the methodological validation be developed during the next phase of efforts (Task 3). To insure the success of the efforts, as well as provide for the significant benefit for the representative systems through OWL analysis, will require long and close collaboration with system and other cognizant personnel. In anticipation of this, personnel were identified during our interviews of users and other selected personnel within the Army (cf., Sect.3.2). Cognizant personnel are currently being contacted regarding the selection of systems and coordination of joint efforts in beginning.

| SYSTEM | OPERATOR | ENVIRON IMPACT | OWL CATEGORY LEVEL | | | | |
|---|---|---|---|---|---|---|---|
| | | | PERCEPTUAL | COGNITIVE | MOTOR | COMMUNICATION | PHYSIOLOGICAL |
| **LOS-F(H)** | GUNNER | MOD | MOD - HIGH | MOD | MOD - HIGH | LOW - MOD | LOW - MOD |
| | SQUAD LEADER | MOD | MOD - HIGH | MOD - HIGH | LOW | LOW - MOD | LOW |
| **ATHS** | COPILOT/ GUNNER | MOD - HIGH | LOW - MOD ? | MOD - HIGH | MOD - HIGH | LOW ? | LOW |
| **AQUILA / IEW-UAV(I)** | VEHICLE OPERATOR | LOW | MOD - HIGH ? | LOW - HIGH ? | HIGH | LOW - MOD | LOW |
| | MISSION COMMANDER | LOW | MOD - HIGH ? | MOD - HIGH ? | LOW | MOD - HIGH | LOW |

Figure 5.3.4-1 OWL Overview for the selected systems

## 6. OTHER PROGRAM PROGRESS

Noteworthy progress has been toward program goals which are tangential to the subject of the present report (re: Task 2). OWL information collection and analysis has been and is underway in preparation for the evaluation of workload measures which is to be conducted as part of the next phase of effort (i.e., Task 3). For the interested reader, details of the status, nature, and methods of this collection may be found delineated in the appendix describing the OWL Information System. The OWL information analysis effort, it is pertinent to observe, is based upon a taxonomy of workload assessment methods with two broad classes:

- Analytic - predictive techniques that may be applied earliest in system design before "man in the loop" studies; and
- Empirical - operator workload assessments that are taken during simulator, prototype, or system evaluations.

Analytic techniques have initially received our greatest interest and attention. This is partially because (although not in the context of the system evaluation objectives of the Army): (1) the empirical techniques have received considerable attention, (e.g., O'Donnell and Eggemeier, 1986); and (2) a model matching empirical techniques with user requirements has been been reported (Casper, et al.,1986) although apparently currently unavailable. Our motivation for focusing on the analytic techniques lies in their application during the earliest developmental stage where the greatest design flexibility is available at the least cost as pointed out earlier in this report (cf., Sect. 2). Thus far, we have classified these analytic techniques into five categories:

- Comparability Analysis -- This category involves the application of existing workload data from an comparable earlier system to estimate the workload for the system under development (e.g., Shaffer, et al., 1986).
- Mathematical Models -- Various mathematical techniques have been used in a theoretical context for a long time. Transfer functions, information theory, and queuing theory are some of the techniques of this category (e.g., Senders, 1964). These provide basic limits or boundaries which may be applied during "front end analysis" with regard to OWL.
- Expert Opinion -- The category relies on the opinion of experts who have intimate working knowledge of the mission objectives, the operational environment and the workload of comparable systems . This category, in contrast to listed below, relies upon experts to identify

choke-points and does not require formal task analyses (Zachary, 1981).

- Task Analytic Techniques -- This category involves the development of a mission profile which represents the way the system is to be used. A number of investigators have used the approach (e.g., Stone, Gulick, and Gabriel, 1985). The profile makes it possible to perform a task analysis for a given work station and translate it into activity profiles as a function of time. This procedure will uncover major situations in which the time available to perform the task (mission) exceeds the time available.

- Simulation Models -- These attempt to model human behavior and thereby predict performance. Some operate at the level of operator tasks (task analysis) to predict level of performance (e.g. Siegel and Wolf, 1969). Others extend the task analysis approach and carry the scenario into far more detail; macro and micro models of components of the task are used to build accuracy and time-line projections of human performance (e.g., Harris, et al., 1986).

We are presently documenting a procedure for the selection from among these analytic categories based on user requirements and resources. As an initial step, this procedure distinguishes OWL comparability analyses from other categories by the requirement for comparable system data. In subsequent steps going from Mathematical Models to Simulation Models, the other categories are distinguished by their increasing requirements for formal system and operator task definitions. Our plan is to shortly complete an overview of our procedure for selection among analytic assessment of OWL (Hill, et al., in preparation).

# 7. FUTURE PLANS

## 7.1 Future Plans for Subsequent Tasks

Task 3 will consist of a critical review and evaluation of OWL measurement techniques (predictive and evaluative) and the development of validation plans for the OWL methodology to be applied to the three Army prototype systems.

Validation plans will be prepared to include OWL measures that offered the greatest utility and impact on the prototype systems described earlier [LOS-F(H), ATHS, and Aquila/IBW-UAV(I)]. For each system , a goal of the validation plans will be to utilize families of OWL techniques. For example, a family of predictive techniques (e.g., expert opinion, simulation models) will be applied to systems in order to assess their relative utility in providing similar types of information before man-in-the-loop simulations. Similarly, a family of evaluative techniques (e.g., subjective techniques such as SWAT, TLX, and Modified Cooper-Harper Scales) will be applied to systems in order to assess their relative utility in providing information during man-in-the-loop evaluations. The validation plans will be structured to be reflective of crew workload issues to the extent possible within the validation effects. OWL analyses will also be directed at ensuring benefit for the selected systems.

In Task 4, the plans generated in Task 3 will be implemented. We will conduct studies to validate the OWL measures and methodology while performing OWL analyses on the three selected systems. In addition to demonstrating and validating the OWL methodology, it is intended that the analyses of the prototype systems will provide significant and direct benefits for the development of these systems. This is extremely important since the success of this OWL program will be direct function of the Army community's reaction to our approach. The more we can document our "successes" in using this methodology, the greater the likelihood that the Army community will be receptive to using our methodology (products).

Task 5 will address the production of the primary documentation of the OWL program. We will produce three products: Manager's OWL Pamphlet, OWL Prediction Handbook and an OWL Evaluation Handbook. A Post-Contract Survey form will be prepared to provide an efficient vehicle to assess the degree to which these OWL

documents have met their goals for the Army. The technical report detailing the scientific basis for the information contained in the pamphlet and handbooks, and discussing further research in the area of controlling operator workload will be prepared as the final product for the Army.

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## DOD PUBLICATIONS

| | | | |
|---|---|---|---|
| DoD Directive | 5000.1 | Major Systems Acquisitions. | 12 Mar 86. |
| DoD Instruction | 5000.2 | Major System Acquisition Procedures | 12 Mar 86. |
| DoD Directive | 5000.3 | Test and Evaluation | 12 Mar 86. |

## ARMY REGULATIONS:

| | | |
|---|---|---|
| AR 40-10 | Health Hazard Assessment Program in Support of Army Materiel Acquisition Decision Process | 15 Oct 83. |
| AR 70-1 | System Acquisition Polocy and Procedures. | 1 Dec 86. |
| AR 70-8 | Personnel Performance and Training Program | |
| AR 70-10 | Test and Evaluation | 30 Apr 86. |
| AR 70-15 | Product Improvement of Material | 15 Jun 80. |
| AR 71-3 | User Testing | 1 Mar 86. |
| AR 71-9 | Materiel Objectives and Requirements | 20 Mar 87. |
| AR 385-16 | System Safety Engineering and Management | 3 Sep 85. |
| AR 602-1 | Human Factors Engineering Program | 15 Feb 83. |
| AR 602-2 | Manpower and Personnel Integration (MANPRINT) in Materiel Acquisition Process | 18 May 87. |
| AR 611-201 | Enlisted Career Management Fields and Military Occupational Specialitites | |
| AR 700-127 | Integrated Logistics Support | 16 Dec 86. |
| MIL-H-46855B | Military Specification: Human Engineering Requirements for Military Systems, Equipment and Facilities | 31 Jan 79. |
| MIL-STD 1472C | Military Standard: Human Engineering Design Criteria for Military Systems, Equipment and Facilities | 2 May 81. |
| AMC Reg. 70-52 | System Engineering | 30 Sep 86. |
| DA Pam. 11-25 | Life Cycle System Management Model for Army Systems | 1 May 75. |

| | | |
|---|---|---|
| DARCOM/TRADOC Pam 70-2 | Materiel Acquisition Handbook | 20 Jan 84. |
| TECOM Pam. 602-1 | Man-Materiel Systems: Questionnaires and Interview Design (Subjective Testing Techniques) | 25 Jul 75. |
| TECOM TOP 1-2-610 | Human Factors Engineering Data Guide for Evaluation | 30 Nov 83 |
| ADS-30 | Aeronautical Design Standard: Human Engineering Requirements for Measurement of Operator Workload. St. Louis, MO: USAVSC. | |

Appendix A

OPERATOR WORKLOAD (OWL) SURVEY

ARI CONTRACT NO. MDA903-86-C-0384

PLEASE RETURN TO:
ANALYTICS INC. ( ATTN: OWL)
2500 MARYLAND ROAD
WILLOW GROVE, PA. 19090
(215) 657-4100 x.164

RESPONSIBILITIES/ROLES IN THE MATERIEL ACQUISITION PROCESS (MAP)

1. PLEASE INDICATE YOUR ROLE(S) IN THE MAP.
(CHECK APPROPRIATE ITEM(S).)

____ DEFINE OR REVIEW REQUIREMENTS, STANDARDS, CRITERIA

____ DEVELOP OR MONITOR THE DESIGN OF EMERGING SYSTEM CONCEPTS

____ DESIGN OR MONITOR THE CHARACTERISTICS OF EARLY PROTOTYPE SYSTEMS

____ TEST AND EVALUATION OF SYSTEMS (EARLY, MID-TERM, LATE) DURING MAP.

____ OTHER (PLEASE SPECIFY:______________________________________________
__________________________________________________________________)

2. FOR OR TO WHOM DO YOU RESPOND - WHOSE TASKS/DIRECTIVES DO YOU USE TO DO YOUR WORK? (CHECK APPROPRIATE ITEMS)

____ OPM (OFFICE PROGRAM MANAGER)

____ TSM (TRADOC SYSTEM MANAGER)

____ DCD (DIRECTORATE OF COMBAT DEVELOPMENT)

____ DOTD (DIRECTORATE OF TRAINING DEVELOPMENT)

____ T&E DIV/BD (TEST & EVALUATION)

____ OTHER (PLEASE SPECIFY: ______________________________________________
__________________________________________________________________)

3. WHAT GUIDANCE AND ASSISTANCE DO YOU USE IN FULFILLING YOUR RESPONSIBILITY? (CHECK APPROPRIATE SOURCES AND SPECIFY)

A. DOCUMENTS:

___ DOD #___________________

___ AR #___________________

___ FM #___________________

___ TM #___________________

___ OTHER DOCUMENTATION (PLEASE SPECIFY: ___________________
_______________________________________________)

B. AGENCIES: PLEASE SPECIFY (e.g., HEL, ARI...)

_______________________________________________

_______________________________________________

_______________________________________________

4. TYPICALLY, WHO USES THE OUTPUT OF YOUR EFFORTS AND PRODUCTS ? (PLEASE SPECIFY)

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

5. HOW OFTEN DO YOU CONSIDER THE FOLLOWING PERFORMANCE AREAS IN FULFILLING YOUR JOB RESPONSIBILITIES?

| (CHECK IN APPROPRIATE BOXES) | OFTEN | SOMETIMES | RARELY | NEVER |
|---|---|---|---|---|
| TOTAL SYSTEM PERFORMANCE | | | | |
| SUBSYSTEM PERFORMANCE | | | | |
| OPERATOR PERFORMANCE | | | | |
| MAINTAINER PERFORMANCE | | | | |

6. HOW OFTEN DO YOU CONSIDER THE FOLLOWING HUMAN PERFORMANCE AREAS IN FULFILLING YOUR JOB RESPONSIBILITY?

| (CHECK IN APPROPRIATE BOXES) | OFTEN | SOMETIMES | RARELY | NEVER |
|---|---|---|---|---|
| HUMAN FACTORS ENGINEEERING | | | | |
| MANPOWER | | | | |
| PERSONNEL | | | | |
| TRAINING : | | | | |
| INDIVIDUAL SOLDIERS | | | | |
| UNIT | | | | |
| SAFETY | | | | |
| HEALTH HAZARDS | | | | |
| OTHER: PLEASE SPECIFY ______________ | | | | |

OPERATOR/ MAINTAINER WORKLOAD

7. DOES THE ISSUE OF OPERATOR AND MAINTAINER WORKLOAD (OWL) LEVEL GET CONSIDERED IN YOUR WORK ?

| OFTEN | SOMETIMES | RARELY | NEVER |
|---|---|---|---|
| | | | |

IF EVER, HOW DO YOU ADDRESS OWL? (e.g., SPECIFIC TOOLS, EDUCATED GUESSES)

8. WHAT SPECIFIC GUIDANCE OR DOCUMENTS DO YOU NOW USE TO ADDRESS OWL? e.g., ARS, LOCAL REGs, SOPs.

9. HOW OFTEN SHOULD THE ISSUE OF WORKLOAD LEVELS BE CONSIDERED IN YOUR JOB?

| OFTEN | SOMETIMES | RARELY | NEVER |
|---|---|---|---|
| | | | |

10. HOW WOULD YOU LIKE TO ADDRESS OWL ?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

11. WHAT GUIDANCE WOULD YOU LIKE TO HAVE FOR ADDRESSING OWL? (e.g. POC, DOCUMENT...)

______________________________________________

______________________________________________

______________________________________________

______________________________________________

12. DO YOU FORESEE AN INCREASED CONCERN WITH OWL DUE TO: (CHECK APPROPRIATE ITEM(S))

_____ CHANGES IN TECHNOLOGY

_____ CHANGES IN REQUIREMENTS

_____ OTHER (PLEASE SPECIFY:_______________________________)

_____ NONE

BACKGROUND INFORMATION

YOUR TITLE :_____________ GRADE / RANK _____________

POSITION:_____________________________________________

YRS. IN CURRENT POSITION: ___________________________

AGENCY / UNIT: ______________________________________

SYSTEMS INVOLVED WITH (NEAR PAST, CURRENT, NEAR FUTURE)

_______________________________________________________

_______________________________________________________

_______________________________________________________

_______________________________________________________

WE WOULD LIKE TO CONTACT PERSONS FURTHER ABOUT OWL ISSUES. IF YOU ARE WILLING TO BE CONTACTED VIA PHONE, PLEASE FILL-IN THE INFORMATION REQUESTED BELOW.

NAME:__________________________ PHONE # :___________

Appendix B

DATE: 9FEB87

# PROGRAM MANAGER'S OPERATOR WORKLOAD ASSESSMENT PAMPHLET

## OUTLINE

USER PROFILE: The intended user for the pamphlet is the program manager who is involved in both delineating the needs, and developing the requirements for a new system. This user is not interested in the details of workload estimation or evaluation. This user also is not interested in which measures or which techniques offer the best OWL assessment. However, what IS of interest to the TRADOC or AMC system manager is high-level guidance on what are the Army requirements regarding workload, and what high-level provisions should be built into the system acquisition strategy for the assessment of OWL.

FORMAT: This Pamphlet will be structured to provide a concise, easily understood presentation of the role of OWL control in the materiel acquisition process (MAP). Tables, charts, flow diagrams, and specific examples will be used liberally to promote quick apprehension of concepts.

GOAL: Provide the reader with an overview of the role of OWL control in the materiel acquisition process, including the nature of the problem, DoD documents and requirements concerning OWL control, and available technologies to assist the Army program manager in effecting OWL control. Provide guidance in accessing other OWL control resources, especially the OWL Prediction and Evaluation Handbooks.

LENGTH: approximately 40-50 pages

CONTENTS

## I. INTRODUCTION

A. Definition of Operator Workload (OWL)

B. Requirements, specifications, standards, and regulations for OWL

C. Impact of OWL on Army Mission Functions

D. Relationship of OWL to MANPRINT

E. TRADOC Contributions in responding to OWL concerns

F. AMC Contributions in responding to OWL concerns

G. Description of the contents of this pamphlet, how to use this pamphlet

STRATEGY: Introduce the user to the key OWL concepts and regulations. Provide the proper framework on how to use this handbook.

## II. OVERVIEW OF OWL FUNDAMENTALS

A. OWL Performance Model

B. OWL with various types of actions/behaviors

1. Searching for and receiving information
2. Identifying objects, actions, events
3. Problem solving
4. Decision making

C. OWL considerations for system types

1. Aviation

2. C3I

3. Air defense

4. Armored/Mechanized operations

5. Maintenance

6. Supply

D. OWL considerations during the Materiel Acquisition Process (MAP)

E. OWL Assessment Program

1. Prediction (analytic approach)

2. Evaluation (empirical approach)

3. Analysis of results

F. OWL Control Plan

STRATEGY: Provide a global "mental map" for the user on the key areas and steps involved in OWL prediction/evaluation and its relationship to the materiel acquisition process.

## III. OWL IN REQUIREMENTS ANALYSIS/CONCEPT FORMULATION

A. TRADOC perspective

B. AMC perspective

C. OWL trade offs in concept formulation

D. Development of a preliminary OWL Control Plan

E. Key OWL resources

1. Documents

2. Organizations (e.g, HEL, ARI)

3. Individuals (i.e., HFE specialists)

F The TRADOC System Manager's (TSM) OWL Concept Formulation Check List

1. What should the TSM be ensuring is accomplished.

G. The AMC Program Manager's (PM) OWL Concept Formulation Check List

1. What should the PM be ensuring is accomplished.

STRATEGY: Provide the user a step-by-step approach to developing and managing an OWL Control Plan during requirements analysis and concept formulation. Provide the user the know-how to integrate the OWL Control Plan with existing requirements, programs, and other control plans that are part of the materiel acquisition process.

## IV. OWL IN SYSTEM DEVELOPMENT

A. The OWL Control Plan

B. Methods for assessment

1. OWL Prediction (analytic approach)

2. OWL Evaluation (empirical approach)

C. Key OWL resources

1. Documents

2. Organizations (e.g., HEL, ARI)

3. Individuals (i.e., HFE specialists)

D. TSM OWL Check List for OWL Prediction

E. TSM OWL Check List for OWL Evaluation

F. AMC PM OWL Check List for OWL Prediction

G. AMC PM OWL Check List for OWL Evaluation

STRATEGY: Provide the user a step-by-step approach to developing and managing an OWL Control Plan during system development. Provide the user the know-how to integrate the OWL Assessment Program with existing requirements, programs, and other control plans that are part of the materiel acquisition process.

## V. ITERATIVE NATURE OF OWL ASSESSMENT

A. Materiel acquisition process

B. System design decisions

C. Evolution of OWL considerations

STRATEGY: Establish the concept that the OWL Assessment Program and its management and control are evolving processes which are modified as the materiel acquisition process progresses.

## VI. EXAMPLE

A. An example will be provided that delineates both TSM and AMC PM development and implementation of their respective OWL Control Plans.

STRATEGY: Provide the user with a concrete example of an OWL Control Plan.

## VII. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

## Appendix C

DATE: 9FEB87

# WORKLOAD PREDICTION HANDBOOK

## OUTLINE

USER PROFILE: The Workload Prediction Handbook is intended for the system designer during the concept and early design phases of the military system acquisition cycle. This user is interested in the different OWL measures and techniques applicable during early design. This user is typically the person who (1) makes the decision of which OWL assessment tools to use, and (2) adapts those tools to fit the specific needs and characteristics for the system of interest. To perform these functions, the system designer will identify the system requirements and specific design objectives for which the workload assessment methodology is needed and will use "the matching model" procedure to select an optimal OWL Assessment Battery. The handbook provides guidance on the implementation of the OWL Assessment Battery.

FORMAT: This Handbook will be organized so to maximize its utility as a working document. Descriptions will be concise and to-the-point. For those users wanting additional background and supporting information, references and appendices will be provided. Decision trees, tables, and charts will be used whenever possible to assist the user in following the methodology contained in the Handbook.

GOAL: Provide the user a step-by-step approach to developing and implementing an OWL assessment program during early system development. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs, and methodologies that are part of the materiel acquisition process (MAP).

LENGTH: approximately 75-100 pages

## I. INTRODUCTION

A. What is Operator Workload (OWL)?

B. Requirements, specifications, standards, and regulations for OWL

C. System performance and operator workload (system requirements)

D. Operator workload performance model: variables/factors to consider

E. Purpose for handbook: methodology for determining and implementing an operator workload assessment program during concept and preliminary design phases

F. How to use this handbook; overview of contents.

STRATEGY: Introduce the user to key OWL concepts and requirements. Orient the user to the critical concept - the OWL Performance Model - that underlies the methodology for workload prediction. Provide the framework on how to use the Handbook.

## II. OVERVIEW OF OPERATOR WORKLOAD PREDICTION

A. What is OWL prediction?

B. The relationship between OWL prediction & OWL evaluation

C. Factors to consider for OWL prediction

1.System requirements, (i.e., system performance)

2.Operator capabilities/skills/behaviors required

3.Stage in materiel acquisition process

4.OWL performance model

5.OWL assessment techniques

D. Matching model for establishing an OWL Assessment Program

STRATEGY: Provide a global "mental map" for the user on the steps involved in workload prediction (analytic approach) and its relationship to OWL evaluation (empirical approach)

## III. OPERATOR WORKLOAD PREDICTION METHODOLOGY

A. Determine system performance requirements

1. Justification

   a. JMSNS (Justification of Major Systems New Starts)

   b. MIL-H-46855B

2. Requirement source documents (cf., DoD Directive 5000.2, AR 15-14, AR 70-1, AR 70-10, AR 71-3)

B. Determine operator actions/behaviors for system usage

1. Sources

   a. Requirement documents

   b. Task analyses

   c. Expert opinions

   d. Comparative systems

   e. Mock-ups

   f. Simulators

2. Classification of operator behaviors/actions required for system usage(cf., Universal Operator Behavior Dimensions - Berliner, Angell, & Shearer, 1964)

   – Chart of Universal Operator Behaviors -

   a. Searching for and receiving information

   b. Identifying objects, actions, events

c. Problem solving

d. Decision making

C. Determine stage in materiel acquisition process

1. Mission area analysis and JMSNS

2. Concept and exploration phase

D. Determine OWL performance model factors to incorporate into matching model (decision making process)

E. Determine OWL assessment program

1. Decision rules for selecting an OWL battery

2. Decision tables for workload methodologies

F. Analytic assessment methods

1. Purpose: Prediction of OWL & "chokepoints"

2. Sensitivity

3. Representation of OWL issues/behaviors

4. Techniques

a. Expert opinions

b. Comparisons

c. Simulations/Models

d. Math models

e. Task analytic methods

5. Interpretation of assessment results

<u>STRATEGY</u>: Provide the user a step-by-step approach to developing and implementing an OWL Assessment Program. Provide the user the know-how to integrate the OWL Assessment Program with existing requirements, programs, and methodologies that are part of the materiel acquisition process.

## IV. ITERATIVE NATURE OF OWL PREDICTION

A. Materiel acquisition process

B. System design decisions

C. etc..

STRATEGY: Establish the concept that the OWL assessment program (developed from using this Handbook) is an evolving program which will be modified as the materiel acquisition process progresses.

## V. EXAMPLES

A. Examples will be provided for each of the assessment techniques.

STRATEGY: Provide the user with concrete examples of OWL assessment programs. Provide reality to the OWL prediction methodology described in the Handbook.

## VI. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

# Appendix D

DATE: 9FEB87

## WORKLOAD EVALUATION HANDBOOK

## OUTLINE

USER PROFILE: The Workload Evaluation Handbook is intended primarily for the TRADOC community as well as system designer involved with early developmental testing (DT&E). These users (e.g., TRADOC) are interested in interpreting the results of the various workload assessments conducted throughout the development cycle but are primarily concerned with system evaluation. These evaluators are responsible for test and evaluation (T&E) but are also (like the designer) interested in how to perform OWL analysis. In addition, they are more concerned than the designer in the actual constraints placed by real-world implementation of a workload assessment. Such constraints involve traditional (and non-traditional) limits on testbed resources (e.g., subjects, time, and funding). The T&E users are also concerned with how to transform OWL data and information into recommendations for system design.

FORMAT: This Handbook will be organized so to maximize its utility as a working document. Descriptions will be concise and to-the-point. For those users wanting additional background and supporting information, references and appendices will be provided. Decision trees, tables, and charts will be used whenever possible to assist the reader in following the methodology contained in the Handbook.

GOAL: Provide the user a step-by-step approach to developing and implementing an OWL assessment program. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs, and methodologies that are part of the military system acquisition cycle.

LENGTH: approximately 125-150 pages

# I. INTRODUCTION



STRATEGY: Introduce the user to the key OWL concepts and requirements. Orient the user to the critical concept - OWL Performance Model - that underlies OWL evaluation. Provide the proper framework on how to use the handbook.

## II. OVERVIEW OF OPERATOR WORKLOAD EVALUATION

A. What is OWL evaluation?

B. The relationship between OWL evaluation & OWL prediction

C. Factors to consider for OWL evaluation

1. System requirements , i.e., system performance
2. OWL assessment program constraints
    a. Subjects
    b. Time
    c. Funding
    d. Etc.
3. Operator capabilities/skills/behaviors required
4. Materiel acquisition process
5. Earlier OWL assessments (OWL prediction)
6. OWL performance model
7. OWL assessment techniques

D. Matching model for establishing an OWL Assessment Program

STRATEGY: Provide a global "mental map" for the user on the steps involved in workload evaluation (empirical approach) and its relationship to OWL prediction (analytic approach), materiel acquisition process, and system design.

## III. OWL ASSESSMENT (TEST AND EVALUATION)

A. Determine system performance requirements

1. Requirement source documents(cf., DoD Directive 5000.2, AR 15-14, AR 70-1, AR 70-10, AR 71-3

B. Determine operator actions/behaviors for system usage

1. Sources

    a. Requirement documents

    b. Task analyses

    c. Expert opinions

    d. Comparative systems

    e. Mock-ups

    f. Simulators

2. Classification of operator behaviors/actions required for system usage (cf., Universal Operator Behavior Dimensions - Berliner, Angell, & Shearer, 1964) - Chart of Universal Operator Behaviors -

    a. Searching for and receiving information

    b. Identifying objects, actions, events

    c. Problem solving

    d. Decision making

C. Determine stage in materiel acquisition process

D. Determine OWL performance model factors to incorporate into matching model (decision making process)

1. For example, environmental factors such as noise, vibration, heat, and cold

2. Sustaining period

E. Determine OWL assessment program

1. Decision rules for selecting an OWL battery

2. Decision tables for workload methodologies

F. Establish framework for the evaluation

1. Task scenarios

G. Empirical Assessment Methods

1. Purpose: Evaluate design decisions

2. Sensitivity

3. Task scenarios: representation

4. Techniques

    a. Operator opinion

    b. Primary task

    c. Secondary task

    d. Physiological responses

5. Interpretation of assessment results

STRATEGY: Provide the user a step-by-step approach to implementing an OWL assessment program - test and evaluation. Provide the user the know-how to integrate the OWL assessment program with existing requirements, programs, and methodologies that are part of the materiel acquisition process.

## IV. ITERATIVE NATURE OF OWL EVALUATION

A. Materiel acquisition process

B. System design decisions

STRATEGY: Establish the concept that OWL assessment (test and evaluation) is an iterative process that is conducted throughout the materiel acquisition process to ensure OWL is not a system problem.

## V. REFERENCES & SUPPLEMENTAL MATERIALS

STRATEGY: Provide relevant references and source material that offer the interested reader additional information on OWL issues. Include annotations and advice as appropriate to guide users in access to and interpretation of materials.

APPENDIX E

## OWL INFORMATION SYSTEM

An OWL Information System is under development to provide for the control and analysis of the mass of documents and other resources comprising the OWL scientific database. Currently under implementation, the system is comprised of several components. One of these is a computerized database, to collect, to organize, to analyze, and to retrieve relevant citations and information associated with those citations. For convenience, we will discuss this aspect in terms of the OWL Information Data Base and the OWL Analysis System. The second part consists of a library consisting of the physical documents keyed to the database for easy retrieval.

Overall, this effort constitutes part of our effort for the development a set of useful tools for the analysis of operator workload, providing decision aids, and an information support system for practitioners.

## OWL INFORMATION DATA BASE

The data base contains standard bibliographic information on each report or article. The software chosen is dBASE III which provides a convenient and widely used relational database and program system for IBM-PC's and compatible machines. The hardware environment was selected to be broadly compatible with government standard microcomputer systems. The overall system is composed of several data files and a number of accompanying dBASE III programs to access and manipulate the data files. Development of the system to this point has been done carefully to provide flexibility in retrieving citations based on particular user needs. Some additional programs will be useful, but these are being done as the need arises.

The OWL reference database now numbers about 1400 reference items and is growing steadily. There are several additional bibliographies which have not yet been entered, for example, one created by Douglas Aircraft Company which consists of approximately 700 items and is supposed to be available soon in dBASE III format. As we

review the actual documents in the database, additional references of interest are being collected from the reviewed documents as well as from direct contact with authors of documents already entered.

The database system was designed to access the information in a number of different ways to accommodate various users, those working on the project and more importantly, those who will be in need of the information when the project is completed. Each bibliographic record is composed of a number of fields as shown in Table E-1. A form has been prepared to facilitate preparation of material for entry into the database (Figure E-1). Of note, are the keyterm (in title) fields which facilitate access by title.

A large number of reports are possible to generate citation listings. The report programs which have been developed to facilitate access of the database are:

- Complete report, alphabetized by authors. This lists all citations.
- Report for all citations for a single author
- Report selecting by keywords, such as "physiological measures" whereby a report is generated that lists all citations under this topic.
- Report listing of references with copies in house
- Several utility reports for editing, etc.

These report programs currently provide bibliographies in two standard forms: Human Factors Society and American Psychological Association. The programs are developed so that others could be added easily. Additionally, several programs have been developed to enter and edit the reference file along with necessary utility programs. The development of these programs allows the user to enter additional references and reviews and still maintain the system easily.

## OWL INFORMATION ANALYSIS SYSTEM

While the bibliographic file will be of general use, the more important part of the data base consists of a separate file containing the reviews produced by members of the Analytics, Inc. OWL team. The reviews are based on objective and standard classification techniques. The review form is shown in Figure E-2 and the structure of the review data

file is shown in Table E-2. This analysis follows the taxonomy presented by Wierwille and Williges (1978) which was in turn, modeled on the taxonomy developed earlier by Berliner, Angell, and Shearer (1964). We have augmented this analysis with the addition of statistical and observer/subject categories, some of which were suggested from an analysis done by Douglas Aircraft Company. Ultimately, most papers will be reviewed.

The reviews are entered into a second, separate data file, linked to the reference file by item number (and first author as a check). (Item No. is an arbitrary number assigned principally on order of entry.) The use of separate files permits multiple reviews (several reviewers) on a given paper and takes advantage of the relational database properties of dBASE III. To date, reviews for approximately 100 papers have been entered; this aspect will receive considerable attention in the near future as we enter into Task 3.

As the number of reviews entered into the system increases, we will develop a report generator to permit the user easy access using the information contained in the reviews.

## OWL LIBRARY

The OWL Library is being assembled through both formal and informal sources. The sources include publications available through DTIC and NTIS, journal articles, conference proceedings, conference papers, monographs, dissertations, etc.

Additionally, documents are being sought directly from well established workload laboratories, e.g., NASA Ames and NASA Langley, Air Force AMHRL, etc. Also, letters are being sent directly to authors already in the database to solicit copies of their work as well as any work which is new or was inadvertently missed on the first pass through other sources. Currently we are receiving 20 to 30 documents a week from authors with approximately 20% being additions to the reference database.

TABLE E-1

Listing and description of fields in OWL reference database

| Description | FIELD NAME | TYPE | LENGTH | DECIMAL |
|---|---|---|---|---|
| Owl database # | ITEMNO | N | 8 | 3 |
| Review done | REVIEWED | C | 1 | |
| Lib. Catelog # | CATALOG | C | 12 | |
| Report No. | REPORTNO | C | 25 | |
| Title - Article | ARTICLE | C | 250 | |
| Title - Book | BOOKTITLE | C | 250 | |
| First Author | AUTHOR1 | C | 25 | |
| Second Author | AUTHOR2 | C | 25 | |
| Third Author | AUTHOR3 | C | 25 | |
| Fourth Author | AUTHOR4 | C | 25 | |
| Fifth Author | AUTHOR5 | C | 25 | |
| Corp. Author | CORPAUTHOR | C | 100 | |
| Vol. Editor | EDITOR | C | 60 | |
| Book Co. | PUBLISHER | C | 80 | |
| Journal | JOURNAL | C | 80 | |
| Year of Pub. | PUBYEAR | C | 4 | |
| Volume | VOLUME | C | 8 | |
| Pages | PAGES | C | 13 | |
| Keyterm | KEYTERM1 | C | 50 | |
| Keyterm | KEYTERM2 | C | 50 | |
| Keyterm | KEYTERM3 | C | 50 | |
| Keyterm | KEYTERM4 | C | 50 | |
| Keyterm | KEYTERM5 | C | 50 | |
| Do we have? | INHOUSE | C | 1 | |
| Notes | NOTES | C | 250 | |
| Date entered | DATE | C | 8 | |

FIGURE E-1

OWL REFERENCE ENTRY FORM

Item No. ________(Assigned by computer)

---

Author 1 : ________________________ Author 2 : ________________________

Author 3 : ________________________ Author 4 : ________________________

Author 5 : ________________________

CORP. AUTHOR: ____________________________________________________

(Use if no authors)____________________________________________________

TITLE:(Journal, Article, Book, or Chapter)

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

EDITOR(s):_________________________________________________________________

BOOKTITLE(For editted books,proceed.):

____________________________________________________________________________

____________________________________________________________________________

____________________________________________________________________________

REPORT NO.________________________

JOURNAL:________________________________________________________

PUBLISHER:(Use only if Booktitle used; Place & pub. company)

________________________________________________________________

Year of Publication: _____ Volume (& No.): _____(___) Pages: ____________

Keyterm 1 :_____________________________________________

Keyterm 2 :_____________________________________________

Keyterm 3 :_____________________________________________

Keyterm 4 :_____________________________________________

Keyterm 5 :_____________________________________________

Copy of Paper in house? __ (Y or N)

Notes:(250 characters)

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

Table E-2.

| Description | FIELD NAME | TYPE | LEN | DECIMAL |
|---|---|---|---|---|
| **GENERAL** | | | | |
| OWL Database # | ITEMNO | N | 8 | 3 |
| First Author | AUTHOR1 | C | 25 | |
| Reviewer | REVIEWER | C | 20 | |
| Review rating | RATING | C | 2 | |
| **REPORT NATURE or TYPE (TYPE)** | | | | |
| DoD | TYPE1 | C | 1 | |
| Theoretical | TYPE2 | C | 1 | |
| Review | TYPE3 | C | 1 | |
| Bibliographic | TYPE4 | C | 1 | |
| Methodological | TYPE5 | C | 1 | |
| Lab Experimentation | TYPE6 | C | 1 | |
| System application | TYPE7 | C | 1 | |
| Specific system | TYPE7S | C | 25 | |
| **FIDELITY (FIDEL)** | | | | |
| Actual system | FIDEL1 | C | 4 | |
| Simulation | FIDEL2 | | | |
| Applied Lab | FIDEL3 | | | |

| | |
|---|---|
| Basic Lab | FIDEL4 |

## ANALYTIC TAXONOMY (TAXA)

| | | | |
|---|---|---|---|
| Expert Opinion | TAXA1 | C | 1 |
| Comparison | TAXA2 | C | 1 |
| Simulation Models | TAXA3 | C | 1 |
| Math Models | TAXA4 | C | 1 |
| Manual | TAXA41 | C | 3 |
| Info Theor. | TAXA42 | | |
| Other | TAXA43 | | |
| Task Analytic | TAXA5 | C | 1 |

## EMPIRICAL TAXANOMY (TAXE)

| | | | |
|---|---|---|---|
| Primary task | TAXE1 | C | 1 |
| Performance rel | TAXE11 | C | 3 |
| Strategy rel. | TAXE12 | | |
| Other | TAXE13 | | |
| Secondary task | TAXE2 | C | 1 |
| Subsid. task | TAXE21 | C | 4 |
| Probe task | TAXE22 | | |
| Dual taks | TAXE23 | | |
| Other | TAXE24 | | |

| | | | |
|---|---|---|---|
| Subjective scales | TAXE3 | C | 1 |
| Rating Scales | TAXE31 | C | 5 |
| CH | TAXE311 | C | 5 |
| MCH | TAXE312 | | |
| SWAT | TAXE313 | | |
| NASA Biploar | TAXE314 | | |
| Other | TAXE315 | | |
| Questionaire | TAXE32 | | |
| Interviews | TAXE33 | | |
| Other | TAXE34 | | |
| Physiological | TAXE4 | C | 1 |
| Heart rate | TAXE41 | C | 10 |
| Heart rate (0.1 Hz.) | TAXE411 | C | 1 |
| Eye movements | TAXE42 | | |
| Respiration | TAXE43 | | |
| Blood Pressure | TAXE44 | | |
| GSR (Skin) | TAXE45 | | |
| EMG (Muslce) | TAXE46 | | |
| EEG (Brain Act.) | TAXE47 | | |
| EP (Evoked Pot.) | TAXE48 | | |
| Body Fluid | TAXE49 | | |
| Other | TAXE40 | | |

| | | | |
|---|---|---|---|
| Type - Mental (TM) | WCTM1 | C | 1 |
| Degree | WCTM11 | C | 2 |
| Duration | WCTM12 | | |
| Type - Psysical (TP) | WCTP1 | C | 1 |
| Degree | WCTP11 | C | 2 |
| Duration | WCTP12 | | |
| Function (FUN) ** | | | |
| Navigation | WCFUN1 | C | 10 |
| Communications | WCFUN2 | | |
| Command decision | WCFUN3 | | |
| Oper. & Monitor | WCFUN4 | | |
| Collision avoid | WCFUN5 | | |
| Path control | WCFUN6 | | |
| | WCFUN7 | | |
| | WCFUN8 | | |
| | WCFUN9 | | |
| | WCFUN0 | | |
| Factors (FAC) | | | |
| Normal Oper | WCFAC1 | C | 3 |
| Time Pressure | WCFAC2 | | |
| Abnormal | WCFAC3 | | |
| Specify | WCFAC3S | C | 25 |

TYPE of SUBJECT (TYPES)

| | | | |
|---|---|---|---|
| Expert | TYPES1 | C | 4 |

| | | | |
|---|---|---|---|
| Novice | TYPES2 | | |
| Student | TYPES3 | | |
| Other | TYPES4 | | |

## TASK DESCRIPTION (TASK)

| | | | |
|---|---|---|---|
| Task 1 description | TASK1 | C | 23 |
| Discrete | TASK11 | C | 3 |
| Paced | TASK12 | | |
| Continuous | TASK13 | | |
| - Response Form (RF) | | | |
| Verbal | TASKRF11 | C | 4 |
| Discrete motor | TASKRF12 | | |
| Cont. motor | TASKRF13 | | |
| Other | TASKRF14 | | |
| - Response Measure (RM) | | | |
| Time | TASKRM11 | C | 4 |
| Accuracy/error | TASKRM12 | | |
| Event | TASKRM13 | | |
| Other | TASKRM14 | | |

| | | | |
|---|---|---|---|
| Task 2 description | TASK2 | C | 23 |
| Discrete | TASK21 | C | 3 |
| Paced | TASK22 | | |

| | | | |
|---|---|---|---|
| Continuous | TASK23 | | |
| - Response Form (RF) | | | |
| Verbal | TASKRF21 | C | 4 |
| Discrete motor | TASKRF22 | | |
| Cont. motor | TASKRF23 | | |
| Other | TASKRF24 | | |
| - Response Measure (RM) | | | |
| Time | TASKRM21 | C | 4 |
| Accuracy/error | TASKRM22 | | |
| Event | TASKRM23 | | |
| Other | TASKRM24 | | |

---

| | | | |
|---|---|---|---|
| Task 3 description | TASK3 | C | 23 |
| Discrete | TASK31 | C | 3 |
| Paced | TASK32 | | |
| Continuous | TASK33 | | |
| - Response form (RF) | | | |
| Verbal | TASKRF31 | C | 4 |
| Discrete motor | TASKRF32 | | |
| Cont. motor | TASKRF33 | | |
| Other | TASKRF34 | | |
| - Response Measure (RM) | | | |
| Time | TASKRM31 | C | 4 |
| Accuracy/error | TASKRM32 | | |
| Event | TASKRM33 | | |
| Other | TASKRM34 | | |

| | | | |
|---|---|---|---|
| Task 4 description | TASK4 | C | 23 |
| Discrete | TASK41 | C | 3 |
| Paced | TASK42 | | |
| Continuous | TASK43 | | |
| - Response Form (RF) | | | |
| Verbal | TASKRF41 | C | 4 |
| Discrete motor | TASKRF42 | | |
| Cont. motor | TASKRF43 | | |
| Other | TASKRF44 | | |
| - Response Measure (RM) | | | |
| Time | TASKRM41 | C | 4 |
| Accuracy/error | TASKRM42 | | |
| Event | TASKRM43 | | |
| Other | TASKRM44 | | |

METRIC QUALITIES (METRIC)

| | | | |
|---|---|---|---|
| Indiv. Differences | METRIC1 | C | 1 |
| Reliability | METRIC11 | C | 3 |
| Stability | METRIC12 | | |
| Other S diff | METRIC13 | | |
| Comparitive Sensit. | METRIC2 | C | 1 |
| Validity | METRIC3 | C | 1 |

| | | | |
|---|---|---|---|
| - Task to task | | | |
| Sub to sub | METRIC31 | C | 3 |
| Sub to obj | METRIC32 | | |
| Obj to obj | METRIC33 | | |
| - Type | | | |
| Content | METRIC34 | C | 3 |
| Construct | METRIC35 | | |
| Predictive | METRIC36 | | |
| Reliability | METRIC4 | C | 1 |
| Test - retest | METRIC41 | C | 4 |
| Split half | METRIC42 | | |
| Alternate forms | METRIC43 | | |
| Interrater | METRIC44 | | |

KEYWORDS (KEYTERM)

| | | | |
|---|---|---|---|
| KEY1 | KEYTERM1 | C | 30 |
| KEY2 | KEYTERM2 | C | 30 |
| KEY3 | KEYTERM3 | C | 30 |
| KEY4 | KEYTERM4 | C | 30 |

COMMENTS (COMMENT)

| | | | |
|---|---|---|---|
| Comment | COMMENT1 | C | 75 |

| | | | |
|---|---|---|---|
| Comment | COMMENT2 | C | 75 |
| Comment | COMMENT3 | C | 75 |
| Comment | COMMENT4 | C | 75 |
| Comment | COMMENT5 | C | 75 |
| Comment | COMMENT6 | C | 75 |

---

Due to the limitation of a maximum of 128 fields in dbase III, a number of the characteristics had to be combined into a single field. The rules for this are based on the estimated probability of searching within a category. For example, Math models from the analytic taxonomy is a single field. The subcategories under math models are a combined field. If Math Models is entered (something other than blank) then you would be asked for the subcategories and these would be stored in TAXA41, in order. Thus, if Infomation Theoretic were the only subcategory, the contents of TAXA41 would look like this '.X.'. (Periods are put into the field when there is no entry. This is done so that if the whole field is printed it is easy to tell where the entry is.)

In the main table, combined entries are indented. Those fields which are combined into another label are blank for field type and length. The example below illustrates this. TAXA42 and TAXA43 are combined into TAXA41.

| | | | |
|---|---|---|---|
| Math Models | TAXA4 | C | 1 |
| Manual | TAXA41 | C | 3 |
| Info Theor. | TAXA42 | | |

Other TAXA43

Further, as the indentation above represents, an indented field will be empty automatically if the main field is blank. Thus, if TAXA4 is blank, the subcategories will also be empty e.g., TAXA41 would be '...'.

In a case where there are subsubcategories, these are listed in the the logical order following the subcategory driving it. TAXE31 has a subcategory of TAXE311, ...,. TAXE311 is a field containing these entries and follows TAXE31 on the dbase III file listing. TAXE32, etc. is stored in field TAXE31.

Figure E-2

## WORKLOAD REVIEWER WORK SHEET

This form will be used until our online:
database system is available:

Instructions to Reviewer:

If Item No. below is blank, please provide full reference, including all authors, title, journal or volume, pages, publisher, year, etc. so we can enter the reference into our database, along with your review.

We have endeavored to design this form to be as easy to use as possible. In the following, please check those items which are relevant to the paper being reviewed. MORE than one item in a category may be appropriate, so please check all appropriate items.

Try to be as complete as possible. Remember, others will be using the information you submit.

For articles which are difficult to locate, it would be appreciated if you would provide a copy for our files.

## REVIEWER WORK SHEET

Item No.: ____________________ Author: ______________________________

(OWL database #) (Last name, initials)

Reviewer: ____________________ Rating: 0 1 2 3 4 5 6 7 8 9 10

(Reviewers subjective evaluation)

REFERENCE:

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

REPORT NATURE or TYPE:

__ DoD (Policy & Implementation)

__ Theoretical

__ Review

__ Bibliographic

__ Methodological

__ Laboratory Experimentation

__ System Application

Specific System: ______________________________

FIDELITY:

__ Actual system __ Simulation __ Applied Lab __ Basic lab 3

REVIEWER WORK SHEET

TAXONOMY

Analytic Procedures

- __ Expert opinion
- __ Comparison
- __ Simulation models
- __ Math models
  - __ Manual control models
  - __ Information theoretic model
  - __ Other
- __ Task analytic methods

Empirical Procedures

- __ Primary task (How many?)
  - __ Performance related
  - __ Strategy related
  - __ Other
- __ Secondary task (How many?)
  - __ Subsidiary task
  - __ Probe task
  - __ Dual task
  - __ Other
- __ Subjective scales
  - __ Rating scales
  - __ CH __ MCH __ SWAT
  - __ NASA biploar __ Other
  - __ Questionaires/Survey
  - __ Interviews
  - __ Other
  - __ WCI/TE
- __ Physiological & eye movements
  - __ Heart rate
  - __ HR (0.1 Hz)
  - __ Eye movements
  - __ Respiration
  - __ Blood pressure
  - __ GSR (skin)
  - __ EMG (muscle)
  - __ EEG (brain activity)
  - __ EP
  - __ Body fluid
  - __ Other

REVIEWER WORK SHEET

WORKLOAD CHARACTERISTICS:

Type __ Mental __ Degree __ Duration
__ Physical __ Degree __ Duration

Function __ Navigation __ Communications __ Command decisions
__ Operation and monitoring __ Collision avoidance
__ Path control __
__ Maintenance __
__ Ground vehicles __ Aviation

Factors __ Normal operation
__ Time pressured
__ Abnormal operation Specify ______________________________

TYPE OF SUBJECT:
__ Expert __ Novice __ Student __ Other

TASK TYPE: e.g., Tracking, visual search, reaction time, etc.

No. 1:________________ __ Discrete __ Paced __ Continuous
Response Form: __ Verbal __ Discrete motor __ Cont. motor __ Other3
Response Measure __ Time __ Accuracy / Error __ Event __ Other

No. 2: ________________ __ Discrete __ Paced __ Continuous
Response Form: __ Verbal __ Discrete motor __ Cont. motor __ Other
Response Measure __ Time __ Accuracy / Error __ Event __ Other

No. 3: ________________ __ Discrete __ Paced __ Continuous
Response Form: __ Verbal __ Discrete motor __ Cont. motor __ Other
Response Measure __ Time __ Accuracy / Error __ Event __ Other

No. 4: ________________ Discrete __ Paced __ Continuous
Response Form: __ Verbal __ Discrete motor __ Cont. motor __ Other
Response Measure __ Time __ Accuracy / Error __ Event __ Other

REVIEWER WORK SHEET

METRIC QUALITIES:

| | |
|---|---|
| __ Individual differences | __ Reliability |
| | __ Stability |
| | __ Other subject differences |
| __ Comparative sensitivity | |
| __ Validity measures | __ Subjective to subjective |
| Task to Task -> | __ Subjective to objective |
| | __ Objective to objective |
| Type -> | __ Content |
| | __ Construct |
| | __ Predictive |
| __ Reliability | __ Test - re-test |
| | __ Split half |
| | __ Alternate forms |
| | __ Inter rater |

KEYWORDS (You need not repeat words from title or words representing items you have checked.)

COMMENTS:

Walraven, J. (1984). Perceptual artifacts that may interfere with colour coding on visual displays. Proceedings of the Workshop on Colour Coded VS Monochromatic Electronic Displays, 13.1-13.11. Royal Aircraft Establishment Farnborough, England: NATO.

Way, T. C., Hornsby, M. E., Gilmour, J. D., Edwards, R. E., & Hobbs, R. E. (1984). Pictorial format display evaluation (Report No. AFWAL-TR-84-3036). Seattle, WA: Boeing Military Airplane Company.